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In this number of the ELECTRICAL REVIEW are gathered together a number of notable contributions to electrical literature, and a series of portraits of those who have contributed to the progress of the art in the last century, that we believe are unique. The history of electricity in its various branches is fully set forth. We feel that none of our readers can fail to appreciate, after he has read the contents, that electricity has been the most potent influence in extending civilization and promoting the general welfare during the last hundred years. Nor can he escape from the conclusion that in the years to come its application, gradually extending, will be the most potential influence in the advance of the human race.

THE ROMANCE OF ENGINEERING.

Many of us are in the same state of mind as the passengers who aroused the wrath of the immortal McAndrews. The coming of steam and electricity has by no means removed the romantic element from our lives, nor is the engineer necessarily a person entirely of figures and diagrams. On the other hand, many of the achievements that have embellished the history of engineering progress in the century just closed have contained spectacular features or elements of human interest of the very strongest.

Think, for example, of the splendid courage shown by the little group of men who laid the Atlantic cable. Was ever greater pluck exhibited in the face of almost insurmountable difficulties, and did ever men so refuse to become disheartened by failure? For years those men studied and wrought, spent their money and their time, contended, on the one hand with every inadequacy of material resources, and on the other with the coldness of public disbelief and even the bitterness of ridicule, and at last triumphed over every difficulty. They must have been possessed of an enthusiasm that counted obstacles as nothing, and it will be noted that this very quality is what carried them to ultimate success, and that their own belief in themselves and in their undertaking was the foundation upon which they built their splendid achievement.

We have all read in our school books of Palissy burning the last miserable sticks and remnants of his humble furniture to fire the kiln in which at last he produced a perfect specimen of porcelain. Is he any finer figure than Gramme, the middle-aged carpenter, laboriously studying out the unfamiliar words of his text-book, and trying to understand the true inwardness of electric generation? We can fancy him, poor, unknown, unfriended, his mind filled with great dreams and immense possibilities, going from door to door and trying to raise the pitiful sum necessary to put his ideas into practice. And at the end of all his labors it was only the generous impulse of a kindly old gentleman that saved his work and made dynamo engineering as it is to-day a possibility. It is stated that when Gramme made his final call on M. Breguet he had gotten as far as the garden gate, empty-handed, when he was called back and given the one-hundred franc note that enabled him to finish his work.

The chance leaving of a cheap Japanese fan in the Edison laboratory made the perfection of the incandescent light a possibility. Everything had been tried as a material for filament making. Seeking for new materials, the inventor discovered that old fan, and taking a strip from one of its ribs, carbonized it. The result was the long-burning light that had been so urgently desired. Then came the diligent search throughout the world for exactly the same kind of bamboo. Men went up the Amazon into the fever-stricken swamps at its source, and were never heard from again. Others tramped through the jungles of Sumatra, meeting strange savages and going into places that white men had never set foot in before, looking for the rare material to make the perfected light of civilization. One man pushed a handcart before him deep into the interior of Japan, where at last the peculiar fibre was found.

Going back to the very sources of electrical engineering, we find that the modern science rests upon the curiosity of an Italian doctor concerning frog legs, which were being prepared for his dinner. It appears that Dr. Galvani's cook hung some fresh frog legs by means of a brass wire hook on the wrought-iron veranda railing of his dwelling. When the wind happened to blow the suspended legs against the railing they twitched, and the learned

doctor noting this fact became filled with a spirit of research, and actually laid the foundation for Volta's marvelous work a year or two later. It is perfectly possible that if Dr. Galvani had not noticed this apparition the beginnings of electricity would have been much delayed, so it is not unlikely that we owe what we are now to the appetite of that learned savant.

The few instances cited above are sufficient to show that the progress of latter-day science and engineering is by no means devoid of the human interest that we call "romance." Science has had its martyrs in every age, and invention and discovery have often followed close upon the feet of accident. We know so painfully little in comparison with the vast unknown that no man can foresee what moment will bring him face to face with a revolutionary discovery. The X-rays, the electric motor, and many other of the commonest applications of electricity in the arts, owe their discovery to pure accidents. Wherever accident or chance enters the opportunity for romance is present, and nowhere does it seem to be greater than in the electrician's art—the dealing with an agency which no man can define and whose possibilities are as yet only dimly foreseen.

OUR PLACE.

Now that the new century has begun and the holiday season passed we are all settling down to hard work, with our faces turned to the front, and our plans—possibly some good resolutions also—all ready and in good working order. In the very foreground of our future looms up largely the fact that this country is rapidly forging to the front as the world's centre of manufacture. We can not escape our destiny, and from present appearances it is to be first in supplying the needs of the world. Industrial supremacy has come to us almost unsolicited. In the nineteenth century we were a small but growing factor in the productive activity of the world; in the twentieth we are surely destined to be supreme.

It can not be too strenuously urged that we should see the truth and profit by it. We have issued suddenly from our national childhood, and we have men's work to do. As we have been leaders in electrical invention and exploitation, so now we shall certainly become the foremost in manufacture, in trade, and in development throughout the world. The magnitude of our own country and the urgency of its needs have perhaps kept us looking too closely at home, forgetful of the bigness of the world outside. This world is now to be our market and the field for our effort.

No one who sees clearly the facts as they are in this matter can refrain from using every effort in his power to convince our manufacturing interests that the time has come for widespread activity. We are most fortunately situated with regard to our internal polity. Our population is prosperous and contented, and we are at peace and likely to remain so. Fortunately for us, we are in a happier position to-day than our more important trade rivals, and if we will only seize the chance that is before us we may, during the next few years, become the financial and commercial emporium of the nations. The electrical interests being in the very front of advance, and dealing with those things that go farthest in the development of other industries, should be particularly interested in the opportunity now presented. We have only to seize what is offered us and hold it; we must not be so foolish or so blind as to let our opportunity go by without making the best of it.

SOME THINGS WE CAN DO WITHOUT.

This is the time when, looking back over the old century and forward into the new, we are rather inclined to sum up the past and use it as some indication of what we may expect in the future. In this connection, as we look ahead it is to be hoped that certain things with which we are all too familiar to-day may disappear before the passing of the next term of a hundred years.

It is sincerely to be hoped that by that time we will be rid of the leaking gas-pipe. It is also much to be desired that our lucky descendants, who will welcome the dawning of the twenty-first century, may regard the horse as a curious animal, much mentioned in history but little seen in their day. In the next few decades it is likely that the lightning-rod agent will become only an evil memory. Frankly speaking, there are a good many developments of our present complex civilization that we could get along very well without, and some of the horrors of modern life will doubtless be palliated by electricity. One thing that is shortening the lives and destroying the nerves of this generation of Americans is noise, and it is really likely that electricity will directly influence the noise-making contrivances now responsible for the hideous din of our cities, so that within one or two generations we may live in practically quiet towns. The yellow newspaper, it is to be hoped, has reached the culmination of its malodorous growth and will decay, especially if some kind of announcing service—electrical, of course—is put in. Here is an opportunity for the inventor; a magnified and glorified sort of "ticker" could be devised which would give us, hot from the press, as it were, the really important news, local, political, foreign, financial, social, etc., instantly, as soon as it could be prepared at proper central offices, and without the intervention of the yelling newsboy or the fearsome head-line. We could have the thing on our desks and see the world's news unfold itself quietly and silently while we work.

The passing of the horse will relieve us of the house-fly; it ought to thin the ranks of the English sparrow also. And we may live to see gardeners take the place of sweepers and mud-scrapers. An automobile charging-plug will be found on every street-corner some day.

Along with noise some of us may live to see smoke and dirt, now considered necessary incidents to manufacture and enterprise, also suppressed, and by electrical agencies. To those of us who have lively imaginations and try to foresee a little of the comfort of our descendants comes a natural regret that we were born so soon; still the electricians have made this world a fairly comfortable place to live in and have doubled and trebled and quadrupled the efficiency of the worker in nearly every direction. It is to be believed, as well as most urgently and earnestly to be hoped, that the same agency that has given us so many conveniences and so many utilities may enable us to get along in the next century without a considerable number of the nuisances that now beset us.

THE TWENTIETH CENTURY.

If some one writing in the early years of the century just passed had been able to portray faithfully the condition of civilization to-day and its dependence upon electricity, he would have been regarded as the wildest visionary who ever put pen to paper. Let this fact, then, be the excuse for what may appear too far reaching a flight of the imagination in the following lines, and forgive an excursion into the tempting field of prophecy.

What will be the greatest effect of the electric arts during this century? Probably the answer may be found in looking at the tendency, already so well developed, of electricity to ally itself with other forces working for the decentralization of cities and the distribution of population. It seems fair to speak of the electric agency as one that has constantly worked for distribution, but what has been accomplished already by it in the spreading of news and information, the scattering of light, power and other utilities over wide areas, and the perfection of transit, enabling the public to live less in huddled tenements and more in the open air, is little indeed compared with what reasonably may be expected of it. For example, it seems that the newspaper must perish some time during the twentieth century, because it will be slow and crude compared with electrical announcing machines in the home or the office. These two, the home and the office, will not need, in that happy day, to be separated, because electrical agencies will enable the business of any man to be done from his home. This of course will come through the perfected telephone, the apparatus for seeing at a distance and other inventions which seem to be potential possibilities. One naturally thinks in this connection, though, of the laboring man, but by reason of the distribution of power for all sorts and kinds of purposes our descendants will do physical labor only for amusement; there will be no necessity for labor as we know it now. This opens to us a vista of speculation that reaches on most alluringly. Divested of the necessity for manual labor mankind will have time to think; taken out of the error-breeding surroundings of the city (for, of course, in a day of universal, swift and inexpensive transit there will be no cities) humanity will be in a position to suppress crime effectually; disease also will be fought from the superior vantage point of proper hygienic conditions and with a battery of improved and perhaps wonderful weapons. Universal peace will probably reign because the telegraph, and other electrical intelligence-transmitting devices, will bring the inhabitants of the world into that closer acquaintance which renders misunderstanding difficult. And the exigences of the universal telegraph and telephone will make certain the adoption of a universal language.

So much, then, for the social results that will be wrought, but what electricity will do for the material side of life is hardly less important or interesting. The horse and the locomotive will be equally objects of a remote curiosity. Coal will be a curious mineral used only for certain chemical products which it contains or which may be made out of it. The skies of the great inhabited regions of the country—the vast suburbs with no concentration of population anywhere and concentration of effort visible only as power-houses where the various natural forces are disciplined—will be smokeless. By that time, certainly, we will have learned how to harness the wind, the tides and the waves, how to seize upon the energy streaming toward us from the sun, and how to tap the vast reservoir of heat in the centre of the earth upon which we live. It seems likely that another century will see electric light almost as abundant and as cheap as daylight, and consequently the work of the world will go on without intermission and the distinction between day and night will become practically unknown. This, indeed, is a very necessary consequence of several forces now at work, for, with the quickening of communication methods, we are bringing together instantly in time places separated widely in longitude, so that the day of one man and the night of another are coincident. Similarly, we will be freed more than now from climatic conditions, either by the regulation of the climates themselves or superior protection against cold and heat, against dust and dampness that electrical devices will afford us.

While means of transportation will be enormously improved in swiftness and capacity it seems now likely that the use for them will decrease. This is because perfected apparatus for hearing and seeing at great distances will render journeys unnecessary, and because the transportation of coal and crude materials will be entirely supplanted by the transmission of electrical energy, either with or without wires, and the relatively less bulky shipment of finished articles. It seems likely that many things which each family does now for itself, such as cooking, will then be done much more economically and with greater satisfaction upon some community system. Indeed it is hard to escape the suggestion that electricity is working in many ways toward the establishment of an ideal socialism. Freed from the restrictions that are placed upon him by environment and by the necessity for labor at ignoble work, the inhabitant of this country at the end of another century should be superior to us in his mental stature almost as much as he will be in the conveniences of his existence. Every new step in progress makes more easily possible those that follow it and hence the speed of progress is accelerating and civilization is moving more and more swiftly toward its state of ultimate perfection. We can not, then, measure the possible growth of another century by the actual increase of the past unless we remember this quickening of pace.

Who can dare even to conjecture what the art of synthetic chemistry aided by electricity will have accomplished in another one hundred years? We may see cultivated fields whereon now is grown the crude material, animal and vegetable, for human food, turned into vast pleasaunces in which our descendants will live while the laboratory manufactures for them, from the materials of the earth and the air, varieties of food better and more satisfactory than the cruder ones to which we are now accustomed. Electricity began its enfranchising career with the car horse and the messenger boy. Is it unreasonable to think that another century will see included among those it has rescued from industrial slavery practically the whole of the human race and all of the brute creation?

The First Century of Electricity.

By Charles T. Child.

IT IS NOT EASY for one living in the swiftly advancing civilization of this first year of the twentieth century to realize the vast debt that society owes to the students, the investigators, the discoverers and inventors who have sought out the laws and put into practice the principles of electricity. So widespread is the influence of the electrician's art, and in so many ways is it woven into the complex of civilization as it exists to-day, that it has become common and familiar and almost overlooked in its more ordinary applications to the service of the individual and the community. Yet it has exerted a social influence wider and deeper and more significant than has any other of the agencies brought to bear upon the progress of evolution within the hundred years just ended.

As one looks back over the history of civilization and attempts to trace to their remoter causes the manifestations of advance, he finds certain points of departure for great movements in discoveries and inventions. Perhaps the greatest of these mileposts in the history of the race is the artificial production of fire, an invention which brought in its train the arts of warming, cooking, lighting, metallurgy and a host of lesser developments. In historical time two great steps forward have been taken:

1. The utilization of the energy of heat for doing work by the steam engine.

2. The discovery of the laws of electricity and their application.

Leaving aside the use of the magnetic compass, which made Columbus's voyage possible and doubled the area of the world, the history of electricity as an effective agency in civilization begins just a century ago. It was in 1800 that Alessandro Volta discovered electric current and some of its more striking phenomena, and invented, in primitive form, the electric battery. This instrument was destined to remain the only source of current electricity for nearly seventy-five years, and upon the energy it generates two of the most important applications of electricity—the telephone and telegraph—have been almost wholly dependent. Volta was a fitting personage to inaugurate a great work; a student, a sincere and far-seeing scientist, a man of affairs, and recognized even in his own time as one likely to accomplish great things, he devoted his life to teaching in his native town of Como. His achievements are an imperishable monument to the glory of Italian science.

During the thirty years that succeeded this memorable discovery absolutely nothing was done towards the application of electricity to any directly useful purpose. But in these years was laid the foundation for subsequent advance by the work of

ALESSANDRO VOLTA.
Discoverer of Current Electricity.

a dozen investigators in their laboratories. Coulomb and Ampère, in France; Weber and Gauss and Ohm, in Germany; Oersted, in Denmark; Davy and Faraday, in England, and Joseph Henry, in the United States, began the magnificent series of researches that culminated sixty years later in the full elucidation of the laws of electricity by Maxwell and planted the seed that has borne such a ripe fruition of usefulness to-day. Still, very little was known of the actions of electricity when Morse began to experiment in order to find out whether he could use the almost unknown agency to send signals to a distance. It was impossible for him to foresee the full success of his undertaking, and he must have gone ahead with that faith which is given to the few men destined to achieve great works. In spite of opposition and ridicule, and in the face of gigantic difficulties, he proved his case and gave the world the telegraph in 1842.

The extraordinary success of Morse's experiment attracted attention from all parts of the world. It was no longer difficult to obtain money for the construction of telegraph lines, and they grew with a rapidity little short of marvelous. Within a few years the country was covered with a network of them; the fact that railways were building at the same time, and that the telegraph was practically indispensable in the operation of trains, adding no little to the zeal with which the building of lines was undertaken. For some twenty years the telegraph remained, however, a means of communication by land only, and it was not until after the middle of the century that it was undertaken to lay wires under water and to communicate between places separated by considerable streams, or even oceans.

Curiously enough, submarine telegraphy was devised more than a century ago. In 1795 Señor Salva, in a paper before the Barcelona Academy of Sciences, suggested the construction of a sort of cable for the transmission of electrical signals, and two years later he definitely proposed submarine telegraphic communication between the mainland and the Island of Majorca. As early as 1803 experiments were undertaken by a nephew of Galvani in sending messages by electric signals under the sea near Calais in France. In 1813 John Robert Sharpe, in England, transmitted electrical signals through seven miles of submerged wire, but perhaps the first real telegraph cable was that constructed in 1839 by Dr. O'Shaugnessy and laid across the Hoogly River at Calcutta, in India. In 1842 Professor Morse laid a cable between Castle Garden and Governor's Island in New York harbor, and actually demonstrated the practicability of submarine telegraphy there. In 1845 a twelve-mile cable, insulated with cotton and enclosed in a lead pipe, was laid by Ezra Cornell in the Hudson River, between New York city and Fort Lee. The first considerable submarine cable was laid across the English Channel in 1850, but this particular cable soon broke down. It was replaced the next year, the date, November 13, 1851, standing as the first on which regular telegraphic correspondence was inaugurated between two countries separated by a sea.

This early cable is interesting in detail. It consisted of four copper wires, insulated with gutta-percha, surrounded by tarred hemp, and protected with an armor of ten galvanized iron wires wound about it spirally. It weighed seven tons to the mile,

and was twenty-five miles long, the greatest depth of water in which it was laid being 125 feet. It was successfully laid from a barge towed by two steamers.

Two years later, in 1853, six cables were put down between England and Ireland and the Continent, the longest one being about 100 nautical miles in length, and all of them proved entirely successful.

In 1857 came the historical attempt to lay a submarine telegraphic cable across the Atlantic Ocean. The enterprise was headed by Cyrus W. Field, in New York, Charles Bright, J. W. Brett and others, in England, and the electrical engineer was William Thomson, later knighted for his admirable researches, and now, since his elevation to the peerage, known as Lord Kelvin, the dean of the electrical engineering profession. This cable was

GEORG SIMON OHM.
Discoverer of Laws of Current Flow.

to extend from Valencia Bay, in Ireland, to Newfoundland, the length necessary being estimated at 2,500 miles. It was of construction similar to that across the English Channel, but, unfortunately, it failed. After 255 miles of it had been laid it broke, and the work was abandoned. The next year, undaunted by the failure, Mr. Field and his associates again attempted the difficult task of connecting the American and European continents with a deep-sea telegraph line. Two vessels were used, the Niagara, of the United States Navy, and the Agamemnon, of the British Navy, each carrying half of the cable and proceeding to mid-ocean, where the ends were joined. They then parted company, sailing westward and eastward, respectively, paying out the cable, and each reached its destination on the same day, August 5, 1858. During the progress of the work the ships remained in communication with one another, and when they landed the shore-ends of their cables for the first time Europe and America were in constant communication. Public rejoicings in both countries were held to commemorate what was believed to be the greatest event of the century. Congratulatory messages were exchanged over the submerged wires between the President of the United States and the

ANDRÉ MARIE AMPÈRE.
Investigator, Mathematician and Physicist.

Queen, and for one month communication was uninterrupted. At the end of that time, however, the cable suddenly stopped working and was never operated further, nor was any portion of it ever recovered from the sea. During its brief career it had carried only 730 messages. It had cost over one and one-quarter millions of dollars, but the chief result that it accomplished was a demonstration of the practicability of submarine cable work. The next year the British Government attempted to connect England with British India by cables laid through the Red Sea and the Arabian Sea, with several inter-

JOSEPH HENRY.
Discoverer of Laws of Electromagnetic Induction.

mediate landings, but this cable also was unsuccessful, working only for about a month.

The subject was one which commanded the deepest attention from governments and engineers. After the failure of the Indian cable a committee was appointed by the British Board of Trade to study the whole matter of submarine cables thoroughly and completely and to report upon it. The report of this committee was that, despite past failures, if sufficient care was exercised in constructing and laying the cable, such undertakings might prove practicable and profitable.

1861 is the date that marks the first successful long-distance cable. This was laid across the Mediterranean from Malta to Alexandria with intermediate landing places at Tripoli and Benghazi. This cable was a permanent success and went into general operation shortly after construction. Its total length was 1,331 miles. In 1864 the British Government laid another cable to India, having a total length of 1,450 miles through the Persian Gulf and the Arabian Sea. This cable also worked admirably.

Meanwhile the great Civil War had broken out in the United States and had, of course, put a stop to such enterprises as cable-laying; but no sooner was it ended.

JAMES WATT.
Inventor of the Modern Steam Engine.

in 1865, than Mr. Field and his associates went to work again on the construction of the transatlantic telegraph. No less than $3,000,000 was paid for a new cable on which, for the first time, steel wire was used for armor; and the Great Eastern, the largest steamship afloat, was chartered and specially fitted up for the work of laying it. The greatest care was exercised in every particular, and when the ship steamed out of Valencia Bay it was thought that at last the difficult problem had been solved. But in mid-atlantic, 1,186 miles out, the cable broke in water nearly 12,000 feet deep, and all attempts to recover it were unsuccessful.

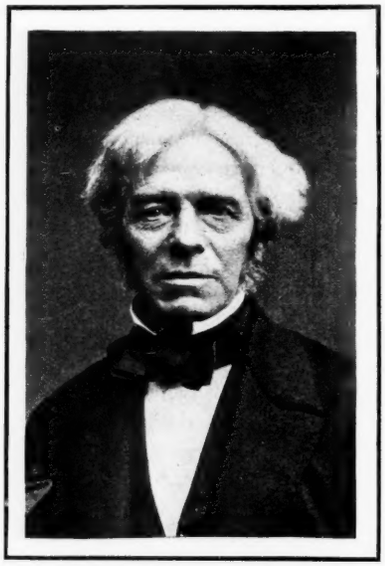
Such a continued series of failures, of accidents, of delays, and so terrible a drain upon their financial resources, would have utterly daunted other men than those who were the pioneers of transatlantic telegraphy. A new company was formed at once by Mr. Field and his associates with the double purpose of finding the end of the cable laid in 1865, and of laying another parallel with and near it. The new cable that was made was similar to

the old one that broke, and the Great Eastern was again used to lay it, having been remodeled to meet the requirements of the work. She left Valencia on July 13, 1866, and arrived in Newfoundland two weeks later, establishing electrical communication across the Atlantic, which has never since been interrupted. Returning, then, to the spot where the submarine wire was lost the year before, her crew succeeded after eighteen days' work in bringing on board the end of the broken cable, which was found to be in perfect working order. A splice was made, and on September 8 of the same year the second cable was landed in Newfoundland and the second line of communication established. The length of this early cable was 2,134 nautical miles, and the rate of speed in transmission was only eight words per minute at first.

SIR HUMPHREY DAVY.
The First Electrochemist and Discoverer of the Arc Light

From that time to the present the deep sea cables have grown in extent and importance, until, with the exception of the Northern Pacific Ocean, the seas are threaded with a network of them, and communication is now possible between any points in civilized countries within a few hours. The movement now on foot, both among private parties and in Congress, to construct a transpacific cable will complete the electric girdle of the world, and, in a way, double the effectiveness and usefulness of all existing long-distance east and west lines, because one may telegraph two ways between any two points when a complete circle of electrical conductors around the world is established.

It is interesting to picture the condition that civilization would have reached by this time if there had been no cables. We scarcely realize how closely woven into our political and social life is the effect produced by great inventions or widespread applications of natural laws. As it is to-day, contrasted with our forefathers, we are practically omniscient. Nothing important happens anywhere in the globe without knowledge of it traveling with incredible swiftness to the remotest regions of the earth. Methods of business have largely been revolutionized, and the politics of the world changed, by the silent agency of the cables. The land-line telegraph in cooperation with them has enabled the formation of national weather bureaus—a thing utterly unthought of by the original promoters of the telegraph. And from the extension of the telegraph and the demand arising for quick communication there came the study that eventually led up to its adjunct, and in many ways its successor, the telephone.

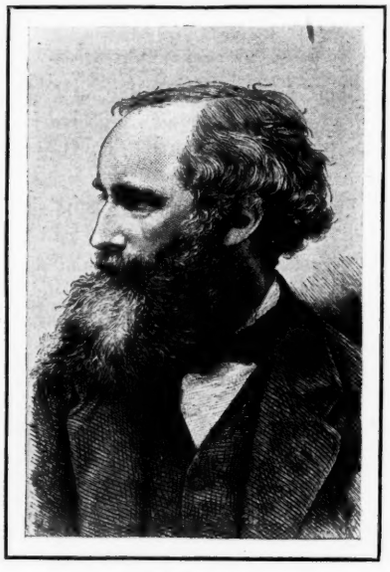


MICHAEL FARADAY.
The Father of Modern Electrical Science.

Of all the inventions that have ever been made the telephone is probably the most astonishing. We are so familiar with it that we forget the daily marvel of intelligent speech transmitted instantaneously to great distances. Two centuries ago the telephone would have been considered sheer witchcraft; to-day it is so common and so much used as to attract little or no attention.

It is useless to tell again here the story of the invention of the telephone. The instrument was first exhibited to the public at the Centennial Exposition in 1876, and in twenty-four years has grown to be one of the most important auxiliaries of business. It represents now an enormous investment of capital and has made employment for hundreds of thousands of people, while it has permitted the emancipation of myriads of messengers to more useful occupations. Some idea of its present importance can be gained by imagining what the result would be if the telephone service of a great city like New York should be, for some cause, stopped. It is difficult to conceive the chaos that would reign in business circles, or the delay and trouble that would be caused by such an accident. The business of the stock exchanges would stop, while the operations of the police and the fire department, the professional business of doctors and lawyers, and the whole activity of commercial firms and individuals, would receive a severe shock. Much more of the world's business is done through the telephone than is generally understood or believed.

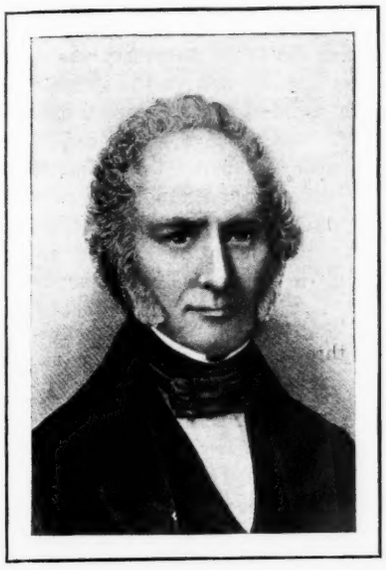
Upon the foundation laid by Professor Alexander Graham Bell in his invention of the telephone a succeeding generation of inventors has built the superb structure with which we are so familiar. For some reason the telephone seems more at home in America and in Sweden than in the rest of the world, its use in these countries being many times greater than elsewhere. For many years the extension of the telephone has been hampered more or less by business conditions surrounding its exploitation, the discussion of which is beyond the province of this article. It is believed, however, by those familiar with the subject that what will be done in the next few years in telephony will be incomparably greater than that done in the whole history of the art up to now. It will not be many years before the tele-



JAMES CLERK MAXWELL.
Author of the Modern Theory of Electricity.

phone is as universal as the water faucet, and when improvements in lines and methods will permit telephony from any place to any other, perhaps largely through the medium of automatic exchanges.

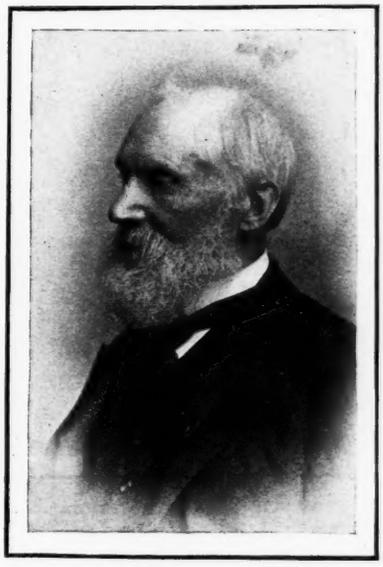
In attempting to demonstrate the truth of certain deductions of Maxwell's, Dr.



WILLIAM STURGEON.
Discoverer of the Electromagnet.

Heinrich Hertz demonstrated the fact that electric waves of greater wave-length than those concerned in light may be produced under given conditions and propagated through space with great velocity. This work remained for several years a monument to the brilliant mathematician and the careful experimentalist, but in 1896 several investigators began to study electric-wave phenomena with a view to their practical utilization. A young Italian, resident in England, Mr. G. Marconi, making use of the sensitive device discovered by M. Branly as an indicator for electric waves, found that their presence could be detected at considerable distances from their source of origin. Hence arose the art of wireless telegraphy, which has attracted a great deal of attention and has been exploited and developed considerably during the last two years. It was foreshadowed by Mr. Nikola Tesla in a lecture before the National Electric Light Association in 1893. So far, however, wireless telegraphy remains rather an interesting application of electrical laws than a practical means for conducting correspondence. Its promise, though, is very large, and it is confidently believed that the near future will see much use made of it both for commercial and military purposes.

Going back now to the beginning of the century, we find that even before the invention of the telegraph the electric current had begun to find uses that were novel and peculiar to it. The application of it to chemical reactions allowed the discovery of potassium and sodium and other metals of the alkaline earths. Its use in electroplating dates from the early thirties when that art was first introduced. It was an easy step from electroplating, or the process whereby substances were covered with a fine adhering film of metal electrically deposited, to electrotyping, where molds were made faithfully, preserving every detail of contour and surface in metal deposited from a bath by electric action. The discovery of electrotyping was one of great importance in the art of printing, leading directly to the cheapening of books, and to the greater



LORD KELVIN.
Engineer of the First Transatlantic Cable.

publication and reproduction of illustrations. Electroplating became the basis of a highly important industrial art employing thousands of operatives, and affording an opportunity for the investment of large capital. Up to about 1874—in other words, for the first three-quarters of the century—the applications of electricity to industry were few and limited, comparatively speaking. At that date the telegraph and electroplating were practically its only important uses. It is since that year, or in the short space of a quarter of a century, that the electric arts have grown to their present enormous importance. In these few years have been invented and brought out the telephone, the electric light, the electric railway, the arts of electrometallurgy, and the chemical processes depending upon electrolysis in some form or other.

Passing over the work of the early experimenters and investigators who endeavored to apply the principles discovered by Faraday in the design of a machine to produce electricity from mechanical motion, the first successful machine was made by Professor Pacinotti, an Italian engineer, but its great importance seems to have been overlooked by him. As it was, it remained for a Belgian, Gramme, to produce what fairly may be called the first practical dynamo electric machine and the type of many others in operation to-day.

Zènobe Thèophile Gramme was born in 1826; his history is a romance of achievement in the face of conditions almost insuperably difficult. At thirty-four years of age he was a carpenter engaged in making railings for staircases in Paris. In that city at the time the old "Alliance" magneto machine was going through its experimental stages in the shops of one Van Malderen. He, being a Belgian, engaged his fellow-countryman, Gramme, as a pattern-maker. This was his first introduction to electricity, and it profoundly impressed and astonished the carpenter to observe the strange performance of the machine upon which he worked. In going from these shops two years later to those of Ruhmkorff, where he was engaged to make the woodwork of static electric

LORD RAYLIEGH.
Physicist and Electrician.

machines and induction coils, he became so much interested in electricity that he deliberately set to work to learn something about it. His education was so deficient that he read and wrote with difficulty, but out of his slender earnings he bought a book on physics and a dictionary, and with the kitchen of his little dwelling in the suburbs for a laboratory, and these

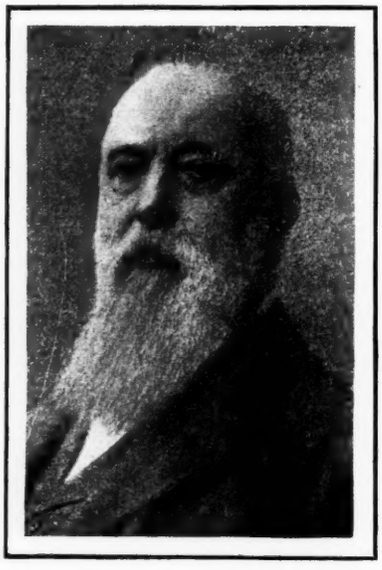
two books for his library, he commenced to study.

To his astonishment he found that so little was known of the subject that it soon could be mastered, and in a short time he was as familiar with it as any one. At about this period of his career he began to invent. For a week or a fortnight he would work at his trade, and then spend his time and his money in experimental work, until hunger drove him back to his bench. It was under such circumstances as this that he designed the now famous type of dynamo machine which bears his name. It was a time of privation in the Gramme household, and after he had pawned all the jewelry and trinkets belonging to the family to make his model machines, the furniture also went to the pawnshop to pay the expenses of his patents. After all these years of labor and hardship he was anticipated four or five days in the announcement of the principle of self-excitation in dynamos. In 1869, after a fruitless journey to England, he was back in Paris trying to raise money to exploit the dynamo, and one day visited M. Breguet, the elder, a man noted as much for his charity and goodness as for his valuable work in physics and optics. He, seeing nothing in the invention, still could not permit his visitor to depart empty-handed, and gave him a note for 100 francs, which was enough to pay the last payment on his patent. Through this the Gramme machine was first made public, its inventor being then forty-three years of age.

In a little while wealth and honors began to flow in upon the obscure inventor, and his name became a household word among the electricians of the world. M. Gramme, who is still living, in Belgium, enjoys the happy distinction of having done more for the technical application of electricity than any other man now alive, and perhaps more than any other who ever lived.

It was shortly after the commercial exploitation of the Gramme machine that the first working arc lamp—the Jablochkoff candle—was introduced. The candle consisted of two parallel rods of carbon separated by porcelain and set in a fixture, with their upper ends connected with a short piece of iron wire. When current was turned on to a candle this iron volatilized at once and formed a path for the arc to play across from one carbon to the other over the surface of the porcelain, which burned away as the carbons were gradually consumed. Crude, and in many ways unsatisfactory, as it was, it was used in lighting the Bon Marché in Paris, a very large dry-goods and department store in that city. Later on a few public places in Paris were also lighted by the candles, and these were the first applications of the electric light in its commercial form. It was only twenty-seven years ago that this was done.

The work of Gramme stimulated a host of inventors to take up the construction of the dynamo and its application for electric lighting. Among them, the Siemens brothers in Germany produced an alternative type of machine for direct current, using instead of the ring armature of the Gramme machine an armature resembling that which was developed by



ZÉNOBE THÉOPHILE GRAMME.
Inventor of the Modern Dynamo Machine.

Wilde in England in his early experiments, while numerous American inventors also went to work on the same fascinating problem. Brush, Farmer, Weston, and Thomson and Houston, brought out in this country designs which were to become the basis of the art of dynamo-building as it stands to-day. Indeed, it may justly be said that the Brush machine and the automatic feeding lamp which its inventor also designed, was the beginning of commercial electric lighting. This machine was put on the market in 1877, and at first was so made that each machine burned one lamp. If two lamps were required, two machines were necessary. The lamp itself was of exceeding simplicity, and its construction of that straightforward kind that has become the hallmark of American engineering products. The principal features of the lamp and the dynamo were that they worked, and that they were able to stand rough handling, and to continue to work in the hands of ignorant persons. As a matter of fact, in that day all persons were ignorant, and it required strong and roughly built machinery to stand the usage that it received.

Beginning with 1877, the electric light began to appear in the streets of American cities, and in a number of semi-public places such as railway stations and docks. But its growth at first was fairly slow. In the first place, the machinery was expensive and bulky, and in the second place, engine builders had not learned the necessity for making engines that could be relied upon to drive electric machinery. The whole art of steam-engine governing as it stands to-day has been developed under the stimulus of necessity for accurate driving in connection with the dynamo machine. This, however, was not particularly true of the arc machines, the principal difficulty in the way of the commercial success of arc lighting being the expense attached to installation and operation. Naturally, the new illuminant met also with strenuous opposition from the gas lighting companies which had been established for many years in all important places.

Toward the end of the decade in which these revolutionary advances had been made, a number of experimenters began work simultaneously upon a type of electric lamp that should operate by the incandescence of some substance. A very large number of semi-incandescent lamps had been designed and made, when Swan in England and Edison in America almost simultaneously produced the lamp which, in its improved form, is now so common. In the early lamps of 1880 are to be found all the elements that enter into the perfected modern lamp in that they consisted of a thin filament of carbon sealed hermetically in a glass bulb from which the air was exhausted.

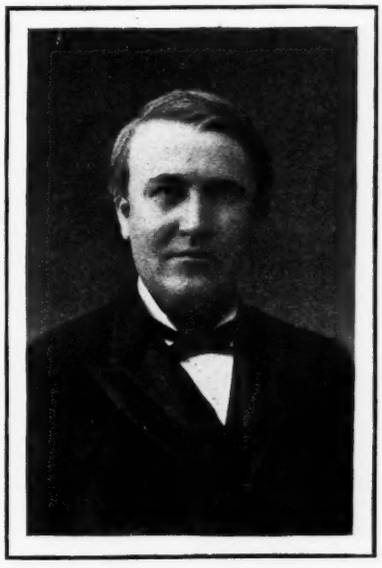
In those days the great desideratum was to divide the electric light. The subdivision of electric current, and the invention and design of lamps of smaller candle-power than the blazing arcs which had first been brought out, was decided to be a commercial necessity. The question was how to do it. It was solved in the simplest, most direct and straightforward fashion by a young American already noted for his meritorious inventions in the field of telegraphy—Thomas Alva Edison.

Mr. Edison's career as an inventor and mechanic is so well known to all American readers that it is hardly worth while here to attempt even to present its salient points. He seemed to see at a glance the commercial possibility of the new light, and went to work on a scale of magni-

tude far greater than anything that had been attempted prior to his time. To him and to him alone is due the credit for the greatest invention in electric lighting—the idea of the central station. It occurred to him that proper sub-division of the light could be made by burning incandescent lamps upon mains or networks of conductors kept at an approximately constant difference of pressure, and that a centrally located generating station could supply light to a considerable area, much in the same way that gas is piped from gasworks. None of the details of the large undertaking which he attempted escaped him. He designed a dynamo which was, for its day, a machine of admirable performance and high efficiency. He also designed methods of switching and handling and saw that conductors for electric lighting must be buried in the earth as gas pipes are, whereupon he designed a complete and fully worked out system of such conductors. Through patient and laborious experiment, covering a long period of time, and costing an almost fabulous sum of money, he developed and improved the incandescent lamp until it became a commercial article that could be manufactured in large quantities and guaranteed as it came from the factory. He also invented the fusible cutout which is certainly one of the most essential and valuable features of any electric lighting system. The opening of the Pearl street station in New York city, September 4, 1882, marks one of the most important epochs in the history of the electric arts.

It was about this time that the urgent necessity for good engine governing became apparent, and the first high-speed engines were produced to drive directly large dynamos laid down in the Edison central stations in New York city. The necessities of the dynamo drove the engine builders to produce entirely new types of steam machines and entirely new methods of governing, so that their speed would be constant within small limits through any range of load. When this was done and these engines had become commercial electric lighting was firmly and thoroughly established as a business, and its growth from that day to this has been steady and constant.

Recognizing the limitations of any low-pressure, direct-current system, limitations which restricted the area over which lights could be distributed economically, many inventors began to seek for a substitute in some system which would permit higher electrical pressures to be used. Perhaps the credit of the development of the alternating-current system will never be properly awarded. It seems to lie between Jablochkoff, the inventor of the candle, and Gaulard and Gibbs, two French inventors, who produced the transformer and used it in connection with electric lighting in France and elsewhere. The first alternating-current transformer systems that were used in this country were introduced as lately as 1883. Immediately there began a wide extension of incandescent lighting, and no doubt the contentions between the advocates of the direct and alternating systems aided no little in educating the public mind (and the contestants themselves) to a fuller appreciation of electric lighting and of



From a copyrighted photograph by J. M. White & Co., Port Huron, Mich.

THOMAS ALVA EDISON.
Inventor and Engineer.

electricity. From the date of this introduction there has been no important development in the art of electric lighting, except the invention of the enclosed arc lamp. This, as every one knows, is a lamp in which the arc burns inside a transparent vessel, which is nearly air-tight, and which, becoming filled with the products of combustion of the carbons, preserves the latter for a period much longer than if they were burned in the open air. Countless forms of such lamps have been introduced but all depend upon the same principle, and they seem destined now to displace all other kinds of lamp for arc lighting. Some promise has been given by the incandescent lamps of Dr. Nernst employing a solid electrolytic conductor heated to a very high temperature by the current, but this apparatus is still in the laboratory stage and has not yet become a commercial product.

Fifteen years ago the electric light was regarded as a sort of curiosity, and while people were interested in it, as people are always interested in any novelty, only the bolder spirits saw in it the possibilities of a great future. To-day it is rapidly driving its rival, gas, out of the lighting field, and into that of heating where it properly belongs. The industry throughout the world represents an investment of capital that can be expressed only in figures of meaningless magnitude. The revenues from it are equal to those of an empire; it gives employment to thousands of people, and it has worked in some ways directly to the benefit and betterment of social conditions in cities and of sanitary conditions everywhere.

As far back as 1833 Jacobi built an electric motor, or engine as he preferred to call it, and with it navigated a boat on the Neva River at St. Petersburg. The classical experiments of Dal Negro in Italy in 1830, of Farmer, of Page, and of Davenport in this country, and of Davidson in Scotland, did really little to develop the electric motor for two reasons; in the first place, most of these inventors were working to produce motion from electromagnetic action through the medium of a reciprocating mechanism, which we now know to be the wrong way to go about it; and in the second place, the only source of electricity that was known to them was the primary battery, and the cost of any reasonable amount of power obtained in this way was absolutely prohibitive. A school textbook in use in the public schools of Boston in 1891 stated that the electric motor was an interesting philosophical toy, but that it could never find practical application because such power cost far more than it was worth!

At an exhibition given in Belgium, somewhere about 1876, the story goes, one of Gramme's workmen in setting up some of his dynamos for exhibition purposes accidently connected a machine that was standing still to one that was running. Instantly the machine that was hitherto still began to turn. It took only a little thought to see that the dynamo itself would be the best possible motor, and that the machine was absolutely reversible. It is believed that there may be some foundation for truth in this story, and that the discovery of the electric motor in its present form was purely accidental. This, so far as we now know, was the first case of electrical power transmission. With the introduction of electric lighting circuits in cities the electric motor began to find a place, small at first but rapidly growing, in industrial life. It furnished a source of convenient, reasonably cheap, and safe power, and was free from the many objections connected with other

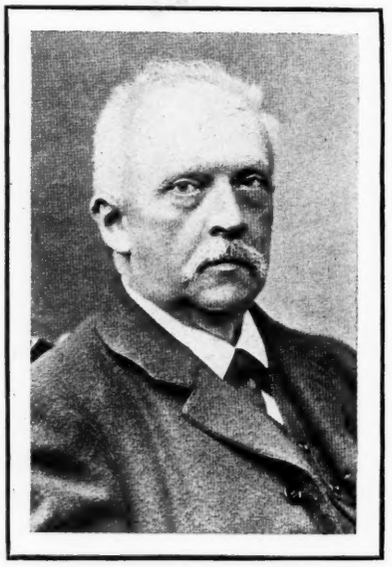
varieties of prime moving apparatus. In some cities central stations were built for the distribution of current for electric motor purposes solely, this being notably the case in New York, Chicago and Paris. More generally, however, the motors were operated directly from electric lighting circuits, especially where these were of the Edison constant-pressure variety.

No sooner had the motor become fa-

HEINRICH HERTZ.
Discoverer of Electric Waves.

miliar to the general public and to electricians than there began a series of experiments with it to see if it were not applicable for locomotive purposes. The idea of the electric railway is an old one. Experimental machines, or rather we should say model machines, driven by batteries, were exhibited in this country as early as 1835. No attempt, however, was made to use electric current for railway purposes on a practical scale, except the remarkable experiments of Davidson in Scotland in 1838, and Page in the United States in 1851, until about 1884. In that year there was built in a suburb of Berlin, by the Siemens Brothers, an electric railway which was the first of the modern type.

It was in the United States that conditions seemed most nearly proper for the development of electric railways on a large scale. In 1887 the now historical Richmond road was built by Sprague, and it became the prototype of the thousand or more trolley roads now in operation in the United States alone. The development of the electric railway was very rapid and was doubtless hastened by conditions which obtained in this country when it was first introduced. There had been a gravitation of population toward cities and the cities had grown inordinately and become densely crowded through lack of means of transit for people to and from their places of business. This lack was supplied, and economically and satisfactorily supplied, by the trolley road, so that from the very beginning a definite commercial and financial success was the lot of the electric railway. The growth of these lines since 1887 has been almost magical. To-day there are nearly 1,000 lines in operation in this country, many of them representing consolidations of from two to a dozen previously existing companies, and the number of passengers carried by them is about five times that carried by steam railways. The capital invested in the electric railway in the United States reaches the enormous total of fifteen hundred million dollars.



HERMANN VON HELMHOLTZ.
Mathematician, Physicist and Electrician.

So far the adoption of electric motors on the larger railways has proceeded slowly. The most conspicuous examples are the elevated railways of New York and Chicago, and the underground railways of London and Paris, where railway trains intermediate in size and weight between those of the main-line railway and the street tramway are electrically operated. Important experiments on a large scale have been made in the United States on heavy electric traction, and every indication at this time points to the equipment within a few years of large numbers of railway lines, especially those traversing the suburbs of important cities, with electrical apparatus.

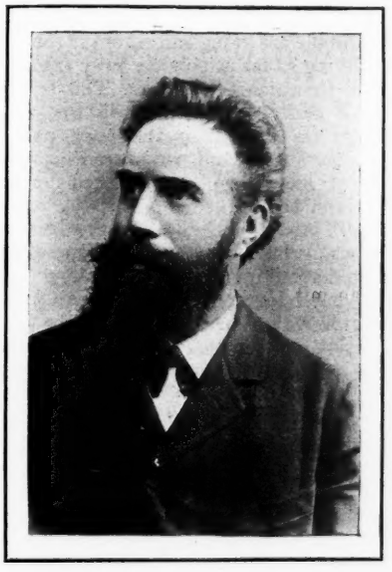
The popularity of the electric motor led to earnest experimental work for the production of some kind of motor that would operate on alternating-current circuits. Alternating current, under certain circumstances and conditions, showed such marked advantages for electric lighting, and was already installed in so many places, that it was felt that the necessity for making a motor that would operate upon it was paramount. At about the same time Galileo Ferraris, in Italy, and Nikola Tesla, in the United States, brought out motors operating by systems of alternating currents displaced from one another in phase by definite amounts and producing what is known as the rotating magnetic field. This invention seems destined to be one of the most important that has been made in the history of electricity. The result of the introduction of polyphase systems has been the ability to transmit power economically for considerable distances, and, as this directly operated to make possible the utilization of water-power in remote places and the distribution of power over large areas, the immediate outcome of the polyphase system was power transmission; and the outcome of power transmission almost surely will be the gradual supersession of coal and the harnessing of the waste forces of Nature to do useful work. Within the last five years there have been built in

ALEXANDER SIEMENS.
Engineer and Inventor.

many parts of the world electrical installations of great magnitude, transmitting the power of cataracts for considerable distances. The longest of these, in California, operates over a distance of 115 miles. Perhaps the largest of them is that at Niagara, where 105,000 horsepower is developed, and much of it trans-

mitted twenty-seven miles to the city of Buffalo.

At the Chicago World's Fair of 1893, there was exhibited a curious instrument for the transmission of handwriting or drawings by electricity, called by its inventor, Mr. Elisha Gray, the telautograph. While it has had little commer-

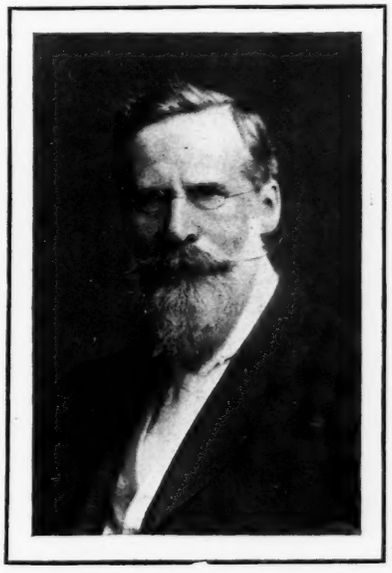


WILHELM KONRAD RÖNTGEN.
Discoverer of the X-Ray.

cial utilization so far, the ingenuity and beauty of the apparatus commend it and lead to the belief that it may yet find extended use.

The action of electricity in decomposing liquid conductors or electrolytes through which it passes early attracted attention and, as mentioned above, some important chemical discoveries were made by the use of this process. When the dynamo had made the production of large currents a matter of certainty, and had reduced the expense of electrical generation, numerous investigators undertook to use the current in chemical operations of one sort and another, both for the reduction and purification of ores, for the synthesis of new compounds, and for the production of staple chemicals from their crude sources. To-day the electrolytic chemical processes, while not spectacular or impressive in the sense that great machinery and other overpowering manifestations of energy are exhibited by them, are still of the highest importance. Practically all the caustic soda and bleaching powder that are used in the world are made by electricity from common salt. Chlorate of potash, from which a series of powerful explosives are manufactured, is made in much the same way. Fifteen years ago electrolytic copper existed only as electrotype plates and copperplating. Now a major part of the American output of copper is refined by the electrolytic process, resulting in a pure and valuable product very cheaply obtained.

Perhaps under this general head of electrochemical manifestations comes an instrument which has given a new outlet to the electrical arts and has proven also of great advantage and benefit in many of the older electrical industries. The storage battery, or accumulator, was first made in its present form by Plantè, in France, and was shown by him before the Académie Française in 1882. The battery was crude and it waited some little time for an important improvement introduced by Faure, which consisted in mechanically applying to the battery

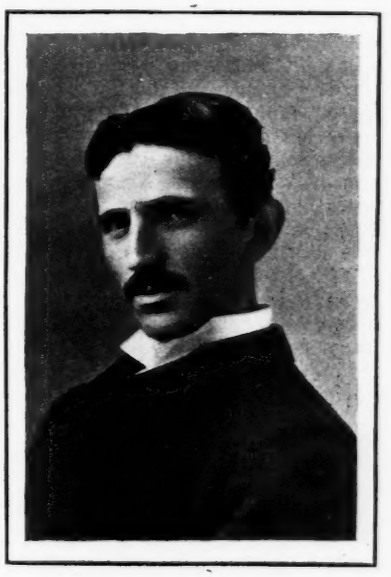


SIR WILLIAM CROOKES
Discoverer of Ultragaseous Space.

plates certain oxides of lead which, in the original cell, were slowly formed by electrochemical action. Of late the storage battery has come more and more prominently into favor as a means for storing a reserve in central stations and as an instantly acting automatic governor for the output of such establishments. It has also made possible the electric automobile vehicle.

Curiously enough, the electric automobile was one of the very first applications of electricity. Davenport's locomotive of 1835, was, to all intents and purposes, an automobile, seeing that it carried its own batteries on its back and propelled itself by electric power. The modern electric vehicle has been developed with great care and after long and expensive experiments. It seems destined to win its way to popular favor and, with other forms of automobiles, slowly to displace the horse from our industrial centres. This, however, is mere speculation; but it is certain that of all forms of automobile in use to-day those operating by electricity run most comfortably, and, for city use, are in all respects the most satisfactory.

Even the earlier experimenters, who noticed the intense heat of the electric arc, were led to attempt its application in some industrial or chemical process. The unrestrained energy of the arc, however, generally prevented this. In it such substances as quicklime and platinum melt like wax, and it was thought that furnaces able to control this powerful heat could never be devised. Like many other modern applications of electricity, now perfected and only dimly foreseen in the past, the electric furnace waited the coming of the dynamo machine and cheap electricity before it could be introduced as a practical industrial appliance. Much of the credit for experimental work upon electric heat belongs to M. Henri Moissan, and to that tireless worker, Dr. William Borchers. Notwithstanding that much of the scientific work on the electric furnace was done abroad, perhaps the greatest use of it to-day is in the United States. The accidental discovery of calcium carbide, used as a source of acetylene, and the invention of carborundum have given a



NIKOLA TESLA.
Inventor of the Polyphase System.

large opportunity to the electric furnace. As yet, however, the industrial work of this remarkable appliance has only begun and its future seems brilliant with prospect for increased use in many perhaps unsuspected directions.

About twenty years ago Professor William Crookes, in experimenting with high vacua, discovered a series of remarkable

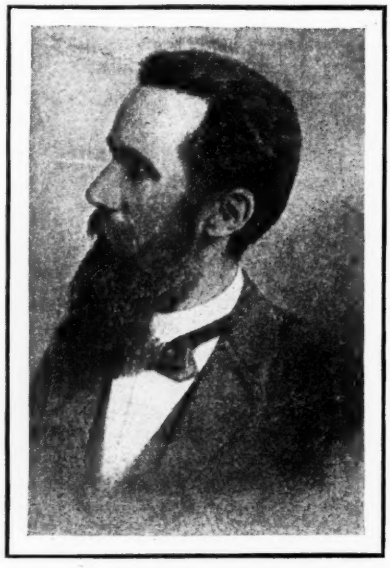
phenomena which led him to conclude that matter might exist in a fourth state, which he called the "ultra-gaseous condition." The beauty and strange character of the phenomena attracted no little attention, and many physicists repeated his experimental work in endeavoring to find additional phenomena belonging to the high vacuum. In 1895, Dr. Wilhelm Konrad Rœntgen, working with Crookes's vacuum tubes in the laboratory of the University of Würzburg, Bavaria, found that from certain of them curious emanations proceeded which affected photographic plates, even though the latter were concealed in holders impervious to ordinary light. The new radiation was named the "X-ray," and it was at once seen that its remarkable property of traversing bodies ordinarily opaque could be used in a number of applications in surgery; for example, by the use of these rays shadows of the bones and other more solid portions of the human body may be cast either upon a fluorescent screen, when they become visible to the eye, or upon photographic plates making a permanent record.

The use of the X-ray in surgery has already been of high value and has contributed no little to the alleviation of suffering and the saving of life. Perhaps of all the applications of electricity to the curative arts this has been the greatest, though a band of ardent experimentalists has endeavored since the early days of the century to find definite applications of electricity in medicine and for the cure of disease. The practice of electrotherapeutics has grown to be of considerable dimensions, and many cures have been claimed to its credit. Among the most remarkable actions of electricity in this connection is that known as cataphoresis. If an electric current flows from an electrode saturated with certain chemical substances, it is found that these seem to be mechanically conveyed by the current without decomposition into the body, and a number of valuable applications of this principle have been made in medicine, and particularly in dentistry.

In 1894-5-6 several electrical inventors gave laboratory exhibitions of "vacuum tube lighting." The devices shown aimed to accomplish illumination by means of so-called "cold light," or a source of light in which a larger percentage than usual of heat rays were transformed into light rays. Long, glass tubes filled with rarefied gas were used as "lamps" and the energy for operating them was supplied by currents of exceptionally high tension. None of the systems has yet become commercial.

This hasty and imperfect sketch of the growth of the various electrical arts may serve to illustrate a few phases of their present status and to indicate the direction of advance for the next century. As we look back over the years of the nineteenth century, crowded with achievement in all directions of peaceful advance as they are, we can not fail to see that the greatest contribution that the science and industry of the world has received in it has been the development and exploitation of electricity. Absolutely unknown as a factor in industrial life at the beginning of the century, we find it at the close entering in a large variety of ways into the daily life of people everywhere and doing a vast part of the increased work of the world. And more than this, we find that the improvements wrought by electricity have been so revolutionary that they have produced entirely new conditions, and that all the conditions they have produced have been good.

What credit belongs to the men who have studied and striven to learn the secrets of electricity and to utilize them



GALILEO FERRARIS.
Engineer and Prominent in the Development of Poly phase Systems.

must be left to the discernment of succeeding generations. It is to be hoped, though, that in the chorus of praise that will ascend concerning the inventor there may not be absent some expressions of approval for the courage of the capitalists whose money paid for the work. When one thinks of the faith exhibited by those who paid for the transatlantic cables, and by those who sank fortunes in the development of the electric light and the electric railway, he can not withhold the praise that is due to the capitalist perhaps no less than to the inventor whose work he encouraged and finished.

The telephone and the trolley car have worked as the most powerful decentralizing influences in the history of the last century. The steam engine, making possible the application of power to labor-saving machinery and to the production of manufactured articles, laid the basis for the factory, and the factory became the centre of the village and then of the town. To these places of labor population was naturally attracted, and settling in the neighborhood of the factories formed nuclei of growing cities. The cities attracted, by the cohesive power of humanity, more and more of the oncoming generations from the country districts. It began to be seriously feared in this country, seven or eight years ago, that the movement of population from the farms and toward the cities would result in some industrial difficulty or in some political situation which would be detrimental to the general welfare. The last census has shown us that, through the agency of the trolley car and the telephone, this centralizing influence has ceased, and that people are going back into the country and living as far as possible away from the places in which they work. This is only one of many direct influences that electricity has had upon the body politic.

Instantaneous and widespread distribution of knowledge accomplished by the telegraph has worked for the peace of the world. About half the disputes between nations arise from misunderstandings. Misunderstanding is not necessary in a day when telegraph wires stretch in a network over the lands and under the seas. In cities, and especially in the more densely populated neighborhoods, the better lighting of streets accomplished by electricity has been a powerful aid in suppressing crime and violence. An arc light is often more valuable than a policeman in a bad neighborhood. Betterments in signaling and automatic indicating devices have reduced the total of fire losses enormously within the century. Had Galveston been swept in 1800 by the hurricane which devastated it instead of in 1900, it is practically certain that all of its inhabitants would have perished, for the reason that the news of the catastrophe would have traveled so slowly that relief of an adequate character could not have reached the place until too late. The cable has made possible the administration of the affairs of China by a concert of civilized nations scattered over the rest of the globe. The telephone has doubled the effective ability of the business men and saved an incalculable number of years of human life that would otherwise have been spent in traveling. Our descendants can look at the threatened failure of the world's coal supply without alarm, since it is now possible to utilize other natural forces that will not become exhausted. And it must be remembered in considering what electricity has done that it has only begun to do these things, and that the whole period of its greatest achievements is included within less than twenty-five years. It is hard to keep from looking ahead and wondering what the future will bring forth and what new uses will be found for the electric current. While it is exceedingly unsafe to prophesy definitely, still no one looking back through this century of progress, remembering that advance in the lines indicated here has moved with an accelerating step, can look ahead into the coming century without a firm conviction that through the agency of electricity the race will go forward more swiftly than ever it has before, and that the conquest of Nature by man, so lately begun, will move rapidly towards its finish and become in time an accomplished fact.

The Telegraph in the Nineteenth Century.

By William Maver, Jr.

THE DEVELOPMENT and growth of the electric telegraph during the nineteenth century is the history of its development for all previous centuries, for, prior to the opening of this century there was, strictly speaking, no electric telegraph. Indeed, it may be said without much exceeding the limits of accuracy, that the history of the development and growth of the electric telegraph for the last two-thirds of this century would contain nearly all that is important concerning that art.

Telegraph systems there were before the electric telegraph. There were telegraph systems even before the Christian era. Writing in 300 B. C., Polybius describes a telegraph system then in use for military purposes. This was a visual telegraph system in which torches were set upon a wall or walls and a certain number and position of the lights were arranged to represent the letters of the Greek alphabet. By changing the position and the number of the lights to correspond to the prearranged plan, it is easy to see how words could be spelled out at one station and received at another. Analagous to this system was the semaphore visual telegraph devised by Claude Chappé, of France, in the latter years of the eighteenth century, and which was, in a more or less modified form, in full vogue throughout Europe in the first half of this century. This system, as its name indicates, "a sign I bear," employed a post and swinging arms, as do the familiar semaphores to be seen along every railway to-day, but the Chappé semaphore was a different appearing arrangement from the ordinary railway semaphore. Thus, there was a cross-arm, about 14 feet long, on the top of the post. At each end of this cross-arm a shorter arm was pivoted and by a system of pulleys and ropes these arms could be placed in many different positions. The letters of the alphabet were allotted certain positions of the arms and thus one familiar with these positions could transmit or receive messages by the proper manipulation of the arms. This system, like all such visual systems, was quite limited as to the distance to which signals could be transmitted between any two stations, and in times of fog could not be operated at all. It is told that during the peninsular wars, when Wellington was fighting the French, a message was received in London by the Admiralty semaphore system, stating "Wellington defeated." A fog intervened, and no further information could be obtained. When the mist cleared, the consternation created by the receipt of the above news was dispelled by the joyful intelligence that the message should have read, "Wellington defeated the French."

It has been well said of the invention of the electric telegraph that it was not the work of any one man. Perhaps the most that can be said of any one man in this relation is that he was the inventor of a particular system of electric telegraphy. The early and late history of this art shows that its advances have invariably followed upon the discovery and announcement of laws and facts of electricity and magnetism. It had, for instance, been known for a long time that many light substances were attracted by an electrified body. Availing of this knowledge, it was suggested as early as 1753, in the *Scot's Magazine,* that if 26 wires were provided, one for each letter of the alphabet, and at the far ends of the wires light pith balls were suspended, messages could be sent over the wires by touching the near end of a wire representing a given letter, by a frictional electric machine, when the pith ball at the distant end of the wire would be attracted. This idea was realized in 1774 by Lesaze, who constructed a short experimental line of twenty-four wires in that year.

The discovery by Volta, in 1800, that electricity could be generated by chemical means was followed by the discovery by Nicholson and Carlisle that water and certain salts could be decomposed by the electric current. Acting upon this knowledge, Sömmering, of Munich, in 1808, devised and operated experimentally an electric telegraph system employing also twenty-five to thirty-five wires for the transmission of letters and numerals, in which this principle was employed, the Voltaic current being caused to decompose water held in small glass tubes at the remote terminals of the wires. The bubbles of hydrogen and oxygen, appearing in certain tubes, indicated the letters transmitted. This was the first telegraph system in which the Voltaic current was employed.

Up to this time and for some years thereafter, the effect of an electric current upon a magnetic needle had not been discovered. The impracticability, however, of making a commercially successful electric telegraph in which twenty-five or

TWENTY-THREE YEARS. From a Portrait on Ivory by Himself. FORTY-SIX YEARS. From a Daguerreotype. SIXTY-EIGHT YEARS. From a Photograph SEVENTY-TWO YEARS. From a Photograph. SEVENTY-FIVE YEARS. From a Photograph.

PORTRAITS, AT VARIOUS AGES, OF SAMUEL FINLEY BREESE MORSE, INVENTOR OF THE ELECTROMAGNETIC TELEGRAPH.

Mr. William Maver, Jr., began his technical connections with electrical matters in 1882 as a multiplex telegraph expert for the Western Union Telegraph Company. He was subsequently electrician for the Baltimore & Ohio Telegraph Company. Since 1880 Mr. Maver has been a frequent contributor to electrical literature on the subjects of telegraphy and electrical underground conduits and cables and is the author of the standard work on the electric telegraph in this country, "American Telegraphy, Systems, Apparatus, Operation." He is a member of the American Institute of Electrical Engineers and of the New York Electrical Society.

more wires between stations were necessary for the transmission of a single message, was evidently apparent even at that early time, for we find Mr. Francis Ronalds, of Hammersmith, in 1816, experimenting with an alphabetical telegraph system in which but one wire was used. In Ronalds's telegraph there was a dial at each station, on which were placed the letters of the alphabet. The dials rotated synchronously. In front of each dial was placed a screen in which a notch was cut, so that as the dial revolved one letter at a time was seen through the notch. Pith balls were connected to the wire at each end. At a given signal the clock-work was started and as a desired letter appeared behind the notch the wire was charged momentarily with frictional electricity and the pith ball was actuated. The letter at that moment appearing through the opening in the dial was noted and in that way messages were transmitted. This was the first synchronous electric telegraph. Ronalds offered this telegraph system to the British Government, purposing to build a telegraph system around the entire British coast, but his offer was rejected in the following language: "Telegraphs of any kind are now wholly unnecessary and no other than the one now in use will be adopted." The one then in use was the visual semaphore telegraph. It may, however, be noted that a subsequent British Government conferred the honor of knighthood upon Ronalds for his scientific work. The incredulity of the British Government at this early period—1815-1820—as to the value of electric telegraphs, need occasion no surprise when it is known that the semaphore telegraph system was not entirely displaced by electric telegraph systems in Europe, or even in this country, until the middle of the century.

The next, and up to that time the most important, practical development of the electric telegraph followed ultimately upon Oersted's discovery, in 1820, of the action of an electric current upon a magnetic needle; namely, that the needle was deflected to the right or left, according to the direction of the current in a wire held parallel to the needle. Taking advantage of this discovery various "needle" telegraph systems came into existence, and were at one time extensively, and it may be added, exclusively, employed in Europe and Great Britain, and indeed still are in limited use there. These "needle" systems as intimated, were operated on the principle just referred to. A magnetic needle was pivoted in the centre of a coil or coils of wire, constituting in effect, and in fact, a galvanometer, and a pointer which was attached to the needle moved in front of a dial. Prearranged deflections of the pointer to the right or left signified a certain letter of the alphabet. The deflections to the right or left were produced by sending over the wire or wires, pulsations of current of one polarity or alternations of both, as required by the letter to be transmitted. The first of these needle telegraph systems was devised by Schilling, of Russia, who employed five needles and one wire for each needle. Gauss and Weber at Gottingen, in 1833, devised and operated an experimental needle telegraph system, using but one wire on a metallic circuit, three miles in length.

Prior to this time it was supposed that a metallic return wire was necessary when the voltaic current was employed, although in many of the early experiments with frictional electricity the earth had been used for this purpose. Shortly thereafter, however, in 1837, Steinheil, of Munich, experimenting in conjunction with Weber, discovered that the earth could be used as a return for a voltaic current. This discovery of Steinheil's was of vast importance in the subsequent development of the electric telegraph, as must be any discovery or invention that will at one stroke, so to speak, practically double the number of existing wires.

Curiously, too, the notion had prevailed up to this period that it was necessary to use wires insulated throughout their length, even when supported on poles, to keep the electricity on the wires. The expense of thus insulating the wires was naturally considered a serious obstacle to the extension of the electric telegraph. Weber, however, removed this obstacle by the important discovery that it was not necessary to insulate aerial wires except at the points of support. Another deterrent to the employment of voltaic electricity in electric telegraphy was the fact that up to 1836 a constant primary battery had not been invented. The invention by Daniell, of Edinburg, of a constant zinc-copper battery in that year, and Sturgeon's previous device of amalgamating the zinc, therefore very materially aided the advancement of the electric telegraph.

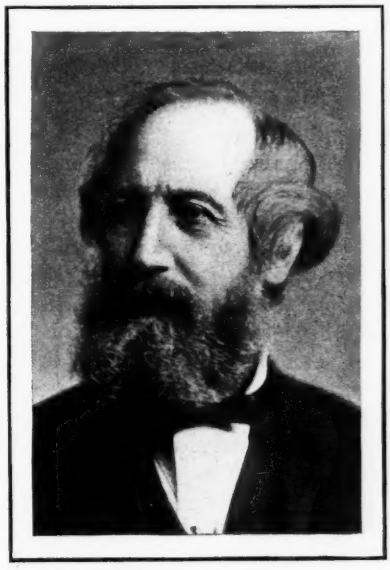
In England, Wheatstone and Cooke, were also assiduously at work about this time, 1835 to 1840, upon needle telegraph systems, and to these inventors belong the credit of having pushed to a commercially successful conclusion the first electric telegraph system. Not that they were the first inventors of such systems, but that they succeeded in working out the details necessary to provide a simple and economical system, which went into very extensive use in Great Britain, especially in the railroad service. These gentlemen evidently had the commercial combined with the inventive talent and took the wise precaution to patent their various devices in electrical telegraphy, for which it is recorded they received from the company formed to exploit their invention over $800,000.

Thus far the discovery of Sturgeon, of England, in 1824, that an electric current flowing in a coil of wire surrounding a piece of soft iron would magnetize the iron, and when the current ceased the iron would lose its magnetism, had not been availed of in electric telegraphy, although Booth, in Dublin, in 1830, and Henry, in 1831, had shown that signals could be transmitted by the means of the attracting power of an electromagnet upon its armature. It remained for S. F. B. Morse, of New York, to put into practical operation the electromagnetic recording telegraph which bears his name, in which the armature of an electromagnet produced on a strip of paper dots and dashes representing the letters of the alphabet, the electromagnet itself being operated by the opening and closing of a key in the line circuit.

The first Morse telegraph line was constructed after many discouragements in 1844, out of public funds, between Baltimore and Washington and was a success. The progress of electric telegraphy into public favor in this country was, however, at first slow. High rates for messages, more or less imperfect service, due largely to poorly constructed lines, and much litigation to preserve the monopoly of the electric telegraph in this country to the Morse interests, were conducive to this slow progress. In 1838 Morse had gone to England to obtain a patent for his invention, but it was refused to him by the Attorney-General on the score of previous publication, a rather flimsy excuse it would seem in view of the facts which briefly were that a statement had appeared in a magazine to the effects that Morse had invented an electromagnetic telegraph. But, a Roland for an Oliver, when Alexander Bain, of Edinburgh, came to this country to obtain a patent for his chemical automatic telegraph, it was refused him on the ground that it infringed Morse's claims. Bain, it is true, used an alphabet of dots and dashes analogous to that of Morse. He employed a device for perforating long and short holes in a strip of paper, the latter being used for the transmission of long and short pulsations of current over

the wire. At the receiving end he employed a strip of paper moistened with a suitable chemical solution, which was decomposed by the passage of current through it, thus producing long and short marks on the receiving paper. As Morse's most important claim was for an electromagnetic telegraph, and Bain did not employ electromagnetism in any shape in his system, it is not easily seen in what the infringment consisted. Bain, more fortunate here than Morse in London, pressed his claim in the Supreme Court at Washington and a patent was allowed. It is doubtful, however, if a British patent would have been of much pecuniary value to Morse had he obtained it, inasmuch as, during the life of his American patent, the Morse system was very sparingly employed in Europe or Great Britain, the various needle and dial systems having secured a strong foothold in those countries.

The next important advance in electric telegraphy in this country was due to Royal House, of Vermont, who invented, in 1846, the printing telegraph system which bears his name. This invention was looked upon at the time as one of the wonders of the age. It was the precursor of the "ticker" and similar printers of today, printing its messages on a strip of paper in roman letters at the rate of fifty to sixty words per minute, as against twenty or thirty words by the Morse system. Dial telegraph systems, due to Wheatstone and others, were also much employed in the middle of the century. These were also known as pointer telegraphs, because of the use of a pointer which, actuated by "step by step" mechanism, passed around the face of a dial, on which were placed the letters of the alphabet, and stopped momentarily opposite a selected letter. Both the House printer and the dial telegraph were believed, in Europe, to give greater accuracy than the Morse system and if the statement made at the time was true, to the effect that an examination had shown that there was an average of one error in every fifth message transmitted by the Morse system, between two important American cities, there was some reason for the belief. After the public mind had accepted electric telegraphy as a practical success and overland telegraphy had become firmly established, it was not long before the feasibility of submarine telegraphy was mooted, and in 1850 the first submarine electric cable of any great length was laid between Dover and Calais, a distance of about twenty-four miles. This was followed by the laying of cables of gradually increasing length, until one of seventy-four miles was successfully laid between England and Belgium. The question of connecting Europe and America by cable now became a subject of serious consideration. "Such a scheme," said a writer of that time (1853-54), "is regarded now pretty nearly as that for the electrical connection of the British Islands with each other and with the European continent was regarded some years ago. The sanguine consider the project practicable, and its speedy realization probable. The more phlegmatic notice it only with ridicule. Men of science generally admit the possibility of the enterprise, while men of finance more than doubt the possibility of a remunerative result."



CYRUS W. FIELD.
The Moving Spirit of the Transatlantic Cable.

After three discouraging attempts a cable was in 1858 laid across the Atlantic, but it was so short lived that those who had previously questioned the feasibility of the enterprise flatly denied that it ever had been successfully operated and would hardly be convinced even by the affidavits of all concerned in laying and operating the cable.

It was due to the untiring efforts of Cyrus W. Field, of New York, that these various attempts to span the Atlantic with an electric telegraph had been undertaken. Nowise daunted by the repeated failures, he continued his advocacy of the scheme, but the Civil War in this country compelled a temporary abandonment of the project. In 1865 a fourth cable was made, but it, too, was broken and lost while in process of laying, by a sudden lurch of the vessel carrying it, the Great Eastern, and it could not be recovered. At each failure, however, new experience was gained which led to the necessary improvements and making and laying the cable, with the result that in 1866 the work was crowned with success and an electric telegraph across the Atlantic was an accomplished fact.

At the beginning of this century it was deemed wonderful that the happenings of the day before in the capital of Great Britain could be read at the breakfast table the next morning, thirty miles out of London, the means for this *rapid* dissemination of intelligence being quick relays of horses and stage coaches. By the completion of the Atlantic cable the same thing was made easily possible between points a distance of 6,000 miles apart, and to-day, by the extension of the electric telegraph over every land and under every sea, no part of the civilized world is in point of time one hour removed from any other part. Lest this should be thought an extravagant statement, it may be noted on the authority of Mr. G. G. Ward, that on one occasion, at least, a *bona fide* business transaction was consummated by means of the electric telegraph between Manchester, England, and Victoria, British Columbia, in one minute and a half.

Between 1850 and 1870, beyond the extension of and improvement in line and cable construction, and in the improvement of apparatus, there was no very marked development in the art of telegraphy. The invention of automatic repeaters in this country, however, in 1848 and 1856, by means of which messages were transferred automatically from the end of one line to the beginning of another, is certainly worthy of passing notice. The Bain chemical system was introduced in 1849 in the United States, and for three years sharply contested the ground with the Morse system and was seemingly in a fair way to outgrow the latter when the rival companies were consolidated, after which the Bain system was gradually withdrawn from service. The tendency in this country after 1853 was towards the general employment of the Morse system, and its use in other countries steadily grew. Even the beautiful Wheatstone automatic system, which, beginning with a speed of 60 to 120 words per minute, is now capable of transmitting over 600 words per minute, is a modification, or refinement, of the Morse recording telegraph. In Europe, and especially in France, much use was made of printing telegraph apparatus, the Hughes printer, invented and named after David E. Hughes, of

Kentucky, 1855, being much employed. The dial telegraph of Wheatstone, in Great Britain, Breguet's, in France, and Siemens', in Germany, were also in extensive use at this period. The Morse recorder in this country, after some years, gave way almost universally to the now well-known Morse sounder, the latter having been found to be more accurate and speedy than the recorder. Attempts also had been made to increase the existing wire facilities, without changing the methods of operation. As early as 1853 Dr. Gintl, of Austria, had devised a system for sending messages in opposite directions over one wire at the same time. He was followed by Frichen and Siemens-Halske, who invented the now well-known differential duplex method. Stark, of Vienna, invented the first diplex method, a means of transmitting two messages in one direction at one time over one wire. These systems were tried, but were apparently too crude to meet the requirements of successful double transmission. Perhaps the demands for increased facilities at the time did not call for continued efforts to improve them. But whatever the cause, up to 1867 these and other systems "had not found their way to any extent to practical application," and it was said without qualification that such attempts at duplex transmission "must be looked upon as little more than feats of intellectual gymnastics—very beautiful in their way, but quite useless in a practical point of view." These words, written, as they were, by one of the foremost scientific men of that day, were not calculated to encourage efforts in this direction.

Not long after this time, however, J. B. Stearns, of Boston, introduced the duplex telegraph system which bears his name. This duplex, in its basic principles akin to the Siemens-Halske differential duplex, was introduced upon the telegraph lines of this country, and, after a short time, in 1872, Stearns added to it the condenser without which the duplex must have remained an impracticable device over long lines. This system at once doubled the existing capacity of every wire on which it was installed, without any change in the Morse system of transmission and reception of messages—a very important feature. The Stearns duplex was followed in 1874, by the Edison quadruplex, which practically increased fourfold the capacity of every Morse circuit quadruplexed. Some idea of the great value of the duplex telegraph system may be gained if we consider its value in submarine telegraphy alone. As previously remarked, there was but one Atlantic cable in 1868, while to-day there are twelve. But each of these cables is now duplexed so that there is the equivalent of twenty-four Atlantic cables in operation, twelve actual and twelve "phantom" cables. In addition to this remarkable development of submarine telegraphy it may be noted that a speed of but three or four words per minute was the maximum obtainable across the first Atlantic cable. By the use of more sensitive apparatus and improved methods, due to Sir William Thomson, Muirhead and others, this speed was soon doubled and trebled, until to-day a speed of about twenty-two words per minute in each direction is attained on these cables, and what is true of the Atlantic cables is relatively true of ocean telegraphy everywhere.

Among other developments in electric telegraphy in the last quarter of the century have been the Delany multiplex synchronous system, by which six and eight messages may be sent over one wire at the same time; this system is now in operation in Great Britain; Gray's harmonic telegraph, by which at least five messages could be sent over one wire at once; this system was operated in this country but was not found so well adapted to the needs of the service here as the quadruplex. In this system tuning forks accurately attuned, respectively, to different rates of vibration were caused to send electric pulsations over the wire, which pulsations were responded to by correspondingly attuned forks arranged as armatures of electromagnets placed in the wire. While a particular transmitting fork vibrated its correspondingly attuned receiving fork vibrated, and would cease to vibrate with it. In this way dots and dashes of the Morse alphabet were transmitted. A very important system was invented in 1882 by Van Rysselberghe, of Brussels, by means of which it is possible to telegraph and *telephone* over the same circuit at once. This system and modifications of it largely used in this country and elsewhere. An analogous system, the Edison phonoplex, by which messages are transmitted by pulsatory signals superposed upon the regular Morse system is also in extensive use in this country. In Great Britain the Wheatstone automatic telegraph is very generally used, especially for press dispatches. The same system is also employed to a considerable extent in the United States. In France, Baudet's printing telegraph system, by which four messages are transmitted at once, is the established multiplex system. In this country the Buckingham printing telegraph system, which is capable of transmitting 100 words per minute on a wire 500 miles in length and delivers the message printed on an ordinary telegraph blank, is the latest successful development of printing telegraphy in actual operation in commercial work. The almost general use of the typewriter by Morse operators in the large cities of this country is one of the more recent developments of the art, and one which in a measure offsets the acknowledged demand of the public for a printed message. In addition to the foregoing there is now an extensive use of electric telegraph in fire alarms, police telegraph, burglar alarm, railroad signaling and many other more or less similar systems.

The commercial growth of the electric telegraph is well shown by a comparison of the volume of business now handled with that of, say, forty years ago, when perhaps 10,000,000 messages were sent annually. To-day doubtless twenty to thirty fold that number are annually transmitted over the wires of all countries, the bulk of which are sent by the Morse alphabet. Of telegraph wires there were in 1840 perhaps 100 miles in Europe and none in this country. To-day there are over 1,000,000 miles of wire in this country alone, a large proportion of which is duplexed and quadruplexed, which adds many hundred thousands of miles of "phantom wire" to the service—wire that, for practical purposes, is as available as the actual wire. And it may be said that what is the case as regards the extension of the telegraph here is relatively the case in the rest of the civilized world, so that to-day the earth is virtually grid-ironed with wires which, to the large majority of those not directly connected with the industry, have been the only tangible and assumedly the most indispensable part of the electric telegraph of which they possessed any knowledge.

It was little wonder, then, that the every-day world stood still in amazement when, four years ago, the announcement was heralded that a system of telegraphy had been invented in which wires were dispensed with and in which that mysterious something, the ether, was utilized, and by which messages were transmitted across miles of free space. Nor, although the scientific world had been measurably prepared for the announcement of the work of Hertz, Branly and Lodge, was it much less lost in wonderment. Not so much, perhaps, at what Marconi had actually achieved as at what the achievement portended for science.

The invention of Marconi's wireless telegraph system was no exception to the rule which the inventions of other elec-

tric telegraphs had followed. Hertz, in 1884, in pursuing his masterly experiments, had demonstrated the accuracy of Maxwell's prediction that electric waves existed in free space. Hertz used a Righi oscillator to set up electric waves. This consisted of a powerful induction coil, the terminals of the secondary wire being connected with two brass balls, between which a succession of sparks jumped while the coil was in operation. For a receiver, Hertz used a ring or quadrangle of copper wire broken at one point. Holding this wire a few feet from the spark gap of the oscillator, the room being darkened, he perceived sparks jumping across the break in the wire, these being due to electric oscillations set up in the wire by the waves radiated from the oscillator. Branly had shown that in the presence of electric waves, metallic filings were affected in such way that their electrical resistance was lowered, and that when the waves ceased and the filings were shaken they resumed their former electrical condition. Here was the equivalent of a key in a Morse circuit. Lodge had shown that the electric waves thus set up, acting upon a Branly "coherer," could be caused to operate an electric bell at a distance of many feet.

Taking advantage of these discoveries and employing the principles of the Righi oscillator, the Branly coherer and his own discovery—the vertical wires at the sending and receiving stations—together with other refinements of apparatus, Marconi has succeeded in transmitting messages a distance in clear space of over sixty miles. There were others who, like Preece, had succeeded in telegraphing across rivers and bays to a distance of three to six miles, by electro-magnetic induction, using telephones as receivers; but, remarkable as such results are, they have not awakened a tithe of the interest aroused by the announcement of the results obtained by the Marconi wireless telegraph, doubtless the most notable development of the electric telegraph in the nineteenth century.

Comparing our present knowledge of things scientific with that at the beginning of this century, when, for example, "the man rash enough to have predicted that within fifty years it would be possible to send a message by lightning from London to Vienna, would have been considered intellectually deranged," what limits shall we place upon progress in any direction during the coming century? Is it too much to predict that within the next one hundred years even the wonderful wireless telegraphy of to-day will be supplanted or supplemented by something even more wonderful?

Historical Notes of Electric Traction.

With a Foreword by Frank J. Sprague.

WHILE the history of the electric railway and its development to its present condition from the crude beginnings of seventy years ago are very fully set forth below, I feel that I should say a few words about the present tendencies in electrical engineering as applied to traction, and about what I believe will be their immediate outcome. I should say, also, here, that I hope the kindness with which my own work has been mentioned in the subjoined historical sketch will lead no one to forget the able and valuable services of my predecessors and contemporaries in the same art.

I believe sincerely that the fundamental departure in railroading which will be most influential in the change from steam to electric traction, will be found to be the ability to operate trains either as a whole or in their detached units. I have called this system the "multiple unit system," of which the broad underlying idea is operation and control, or the control by electrical means, partly or wholly through a secondary circuit, of any and all reversers and switches for grouping and other purposes, either independently or collectively, at the same or different times, however combined or grouped and wherever placed, whether these be on a single car or on a train. And this with one or more fully or partially equipped cars, which may preferably be connected in any desired way or end relation with one another, so that the various equipments may be operated either locally or from one or more distant points.

This is the system which was initiated on the South Side elevated in Chicago in 1897, which has been adopted on the Brooklyn and Boston elevated railways, and which is on the eve of adoption on other important lines.

I do not think it is safe to say that the electric locomotive will generally supersede the steam locomotive. If a steam railway adopts electric traction its service system must be practically changed; smaller train units completed within themselves, operated independently or in combinations, must be used; the motors must be distributed throughout the different cars and, so soon as this is done, direct hand control must be done away with in favor of a secondary control of a more or less automatic character. I do not believe that we can compress upon a single unit the power necessary to do the service done to-day by the steam locomotive. I do believe, however, that it is perfectly possible to consolidate any number of units equipped with any amount of power under a common control.

The saving of coal is not the criterion by which we should measure the urgency of the adoption of electric traction. The all-important consideration is capacity for increased speeds, and the making of train lengths and intervals subject to the will of the traffic superintendent. What we want is the ability to get and to accommodate service and traffic. Service must be changed with the change of motive power.

As I look at the past history of the electric railway and see the development that has taken place and is now going on, I am more and more fully convinced that it is in this way the change from steam to electric traction will be made, and that instead of the cumbrous and high-powered single locomotive hauling a train of cars, we will have, on the railroad of the future, trains of any length that the service demands; each transportation unit, whether composed of one or more cars, being independent of all the others and capable of independent motion; yet all, when coupled together in trains, controllable and directed from the front end of, or any selected point in the train by a single simple system of manipulation. This, I think, is the direction of immediate future advance.

FRANK J. SPRAGUE.

New York, January 3, 1901.

PERHAPS, if one goes out upon the streets of one of our cities to-day and looks about him for evidences of the work of electricity, the most striking and apparent of them that he will find will be the trolley car. Again, one searching statistics and other sources of information to discover what influence has exerted itself most largely for the benefit of the community in general during the last generation, will find the same ubiquitous vehicle. Yet the development of

electric railways as they now are is a matter of only little more than a decade; and this development, in its commercial and active form, is also almost peculiarly American, and therefore a thing concerning which we may take no little pride.

While it is true that the commercial exploitation of the electric railway has been almost entirely American—as was the early research that laid the foundation for knowledge of the subject—still perhaps the greater part of the scientific study that led to the perfection of the present-day systems was conducted abroad.

In the year 1830 an Italian priest, the Abbe Salvatore Del Negro, professor of natural philosophy in the University of Padua, made the first electric motor, which was a reciprocating apparatus—a mere toy—but nevertheless the prototype of the magnificent machinery of the modern electric railway.

The first attempt to build an electric railway, of which there is any record, was made by Thomas Davenport, a blacksmith and wheelwright of the town of Brandon, Vt. He built, strangely enough, an electric automobile in the year 1835. For a motor he had a revolving electromagnet running between fixed soft iron armatures or pole pieces, carrying upon the revolving shaft a commutator which properly handled the current. The whole thing was mounted on a car containing several cells of battery and was exhibited running on a circular track at Boston and at Springfield, Mass., 65 years ago.

The next, and up to very recent years the most ambitious, attempt at electric railroading was made by Robert Davidson, of Aberdeen, Scotland. Mr. Davidson was far in advance of his time. He saw that some day the steam locomotive, then just beginning its career of usefulness, was destined to be supplanted by electric apparatus, and in order to demonstrate the feasibility of electricity as a motive power on railroads he built, in 1838, an electric locomotive of really considerable power. The machine ran on standard gauge railway tracks and was built on a platform five feet wide and 16 feet long. It carried 40 cells of battery, each cell having plates 12 by 15 inches in size, of zinc and iron, immersed in a solution of sulphuric acid. Together with the motor and batteries the locomotive weighed over five tons. The motor consisted of a pair of drums, one being connected by a sprocket gear with each axle, and each drum carrying sets of soft iron bars parallel to its axle. Upon the floor of the car were mounted eight large electromagnets in two rows adapted to attract the iron bars on the face of the drums, and governed by a commutator carried around with the drums so that their attraction ceased as each bar passed its appropriate magnet. Despite the inefficiency and crudeness of this motor the machine made a number of very successful trips on various railways in Scotland, and was regarded as one of the wonders of the age. It evoked the most determined hostility from the locomotive engineers and stokers of the period, and one night, while stabled in the engine-house at Perth, it was broken and practically destroyed by some miscreant. Of course suspicion fell on the locomotive engineers, where it seems rightfully to have belonged.

Mr. Davidson satisfied himself by these experiments that, while electric traction with automobile locomotives of this type was possible, the cost was prohibitive, so for many years nothing more was done in his country in this direction.

Twelve years later, in 1850, Professor C. G. Page, of the Smithsonian Institution, at Washington, constructed a large electric automobile motor of 10 horse-power. The machine operated so well that he made another of 16 horse-power adapted to run on standard railway tracks. He used reciprocating motion obtained by pulling an iron core into a hollow solenoid which was divided up into sections, these being properly commuted to give a long steady pull. The machine carried 100 flat Grove cells, in which the platinum plates were 11 inches square. On April 29, 1851, it was taken out on the tracks of the Baltimore & Ohio Railroad and made a round trip to Bladensburg, Md., developing speeds as high as 19 miles per hour. Great trouble was encountered from the breakage of the porous cups in the battery cells and after some further experiment the project was abandoned, Professor Page having reached the same conclusion that Davidson had arrived at some years before.

About the same time Moses G. Farmer was experimenting on electric railways on a small scale, and the year before had constructed a small locomotive and one car capable of carrying two passengers and running on an 18-inch gauge track. This machine carried on board of it 40 pint Grove cells. The next year Mr. Farmer built another model for the Massachusetts Charitable Mechanics Association fair at Boston. This ran on a little track five inches gauge and about 40 feet long, so arranged that at each end a reversing switch stopped the motor and started the car in the reverse direction. The motor employed was of the type devised by Professor Page, in which an electromagnet rotated between the poles of a permanent horseshoe magnet. This worked through a worm-gear to a counter-gear, which engaged with a gear on the axle. Current was supplied to the motor through the rails, these being insulated from one another, so that this early device embodied two principles that have been carried to high perfection later and appear in the majority of modern installations. One of these is the principle of speed reduction, permitting the employment of a high-speed motor, and the other is the feeding of a locomotive motor from fixed conductors.

Even earlier than this, however, the same principle had been developed, with particular regard for its application to telegraphy to trains, by an Englishman named Henry Pinkus. A British patent of 1840 granted to him covers the transmission of electric current from fixed conductors to a moving train. Patents in France and Austria, granted in 1855, to Major Alexander Bessolo, of the Italian army, exhibit the third rail, used, however, for telegraph purposes only. For over 20 years nothing was done in the direction of developing the electric railway. The inventors of the earlier day, whose efforts are sketched above, had all reached independently the same correct conclusion—that the expense of generating electricity in chemical batteries was too great to permit its application for railway purposes. It was necessary, then, to wait for the perfection of the dynamo before further work could be successfully undertaken.

In 1864 Professor Pacinotti devised his now famous dynamo, and three years later Wheatstone, in England, and Werner Siemens, in Germany, independently brought out the principle of the self-exciting dynamo. About 1873 Gramme made his accidental discovery of the reversibility of the dynamo, while in the same year MM. Fontaine and Breguet exhibited a dynamo working as a motor at the Vienna Exposition.

Perhaps the first work that was done on the modern electric railway was that of Mr. George F. Greene, of Kalamazoo, Mich. In 1875 Mr. Greene constructed a model railway, generally similar to Farmer's model but larger. He used also the track rails for conductors. In 1879 he built a large car, seating two passengers. He fully recognized the necessity for a dynamo machine to furnish his current, but being then a poor mechanic he was unable to raise the necessary funds, and it was not until August, 1879, that he applied for patents. Without the

means to employ competent attorneys his patents languished in the office for 12 years and were not finally granted until 1891.

Meanwhile in France, in the Spring of the same year, the first experiments in power transmission on a commercial scale were conducted in the neighborhood of the beet sugar works at Sermaize, near Paris, fields being ploughed by electric motors of several horse-power driven from a dynamo a third of a mile away. In the Summer of 1879 Siemens and Halske exhibited at the Berlin International Exposition an electric locomotive and one car. The installation was upon an oval track about 1,000 feet in circumference and a third rail was used as a source of current supply. The motor was a small Siemens dynamo, and its shuttle armature was connected by double-reduction gearing with one of the axles. The car carried 20 passengers and made a speed of about eight miles per hour. This may fairly be called the first working electric railway of full size.

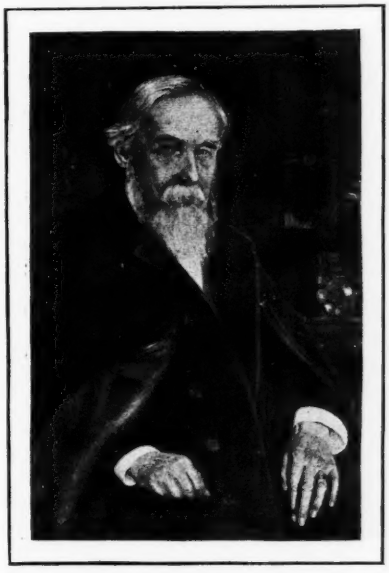
The next year, 1880, Mr. T. A. Edison made his first experiments in electric railroading, as did also Mr. Stephen D. Field, the latter obtaining some priority in the patent office by reason of a caveat filed in May, 1879. The contentions between these two inventors probably did more than anything else to delay the exploitation of the electric railway in America. Meanwhile, in 1881, Siemens and Halske opened a third-rail line in Berlin, which was the first commercial electric railway in the world. During the Summer of the same year they changed over the Charlottenburg and Spandau horse-car line, equipping it with an overhead wire system.

The year before, 1880, experiments were made with an accumulator car on a track about one mile long at the linen bleachery of M. Duchesne-Fourmet, at Breuil-en-Auge, in France, and in the Summer of the next year an accumulator car was also put on the Vincennes tramway line in Paris.

The scene now shifts to Ireland, where, in the early Summer of 1883, a project was started for building a six-mile tram line to the Giants Causeway, near Portrush. Dr. Werner Siemens undertook the electrical equipment of the line and it was opened to the public on November 5 of that year. A pair of turbine wheels actuated by a water fall on the River Rush, about one mile distant from the line, supplied the necessary power and a third rail was used as the conducting system.

It was during this year that the real work of electric traction in the United States was begun, the consolidation of the Field-Edison interests and the formation of the Electric Railway Company of the United States being the first step in this direction. The company was formed in May and by almost superhuman efforts on the part of the inventors and others a section of experimental railway was laid for exhibition at the Chicago Railway Exposition of June. About 1,500 feet of three-foot gauge track was laid in the gallery of the main building. Upon this was operated, by means of a third-rail conducting system, a model electric locomotive. The track was bonded to better its conductivity, this being the first recorded instance of rail bonding.

The Autumn of the same year at the State Fair, held also in Chicago, an over-



MOSES G. FARMER.

head line was exhibited by Mr. C. J. Van Depoele. At about the same time Mr. Leo Daft equipped a short length of railway running from Saratoga Springs, N. Y., to Mt. McGregor. Upon this was operated a 12-horse-power locomotive hauling a 10-ton passenger car, which accommodated 68 passengers. Gradients of 93 feet to the mile were easily overcome and an overall speed of about eight miles per hour maintained. The conducting system was a third rail, 35-pound iron T-rail supported on rosined wooden insulators being used and speed control being obtained by commutation of the field coils of the motor. The next Summer Mr. Daft built a short line on the iron pier at Coney Island, near New York city, and although this was completed late in the season it carried 38,000 passengers before it was closed for the Winter.

While this was going on Messrs. E. H. Bentley and Walter Knight constructed, in Cleveland, Ohio, what was perhaps the most remarkable of the early roads and one that was the first to enter upon active competition for passengers with horse cars. It was an underground conduit road about two miles long. The conduit was of wood and was laid between the rails of the track. The motor was suspended from the body of the car between the two axles and was belted to them by wire rope belts. The system ran successfully in Summer and Winter for more than a year when Messrs. Bentley and Knight went to Providence, R. I., to engage upon larger work. It may be said here that later installations by these same inventors came very near establishing the success of the "underground trolley" system nearly 12 years before it was definitely adopted in the United States. A line was constructed across New York city through Fulton street—a crowded thoroughfare in the business section of the city—and we can see now, in retrospect, that it failed of success by the narrowest margin. The same makers constructed a conduit line in Boylston street, Boston, Mass., which also came very near successful operation, but failed in a few particulars so that overhead wire construction was adopted afterward in that city.

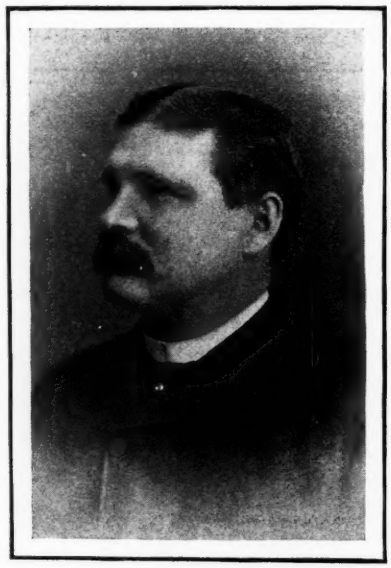
The first practical overhead line in the United States, if not in the world, was that constructed in the Autumn of 1884, between the Market Square, in Kansas City, Mo., and the suburb of Westport, by Mr. J. C. Henry. Two overhead conductors were installed and sometimes these were used as the feeding and return conductors and sometimes both together as the positive conductor, the rails being used for the return circuit. They consisted of hard drawn copper wire of No. 1 B. & S. gauge, which, at that time, was made only in lengths of about 75 feet and had to be brazed together on the ground. Upon the one car which was used was installed a five-horse-power Van Depoele motor, of the constant-current type adapted for use on arc light circuits. This machine was geared by differential gearing, greatly resembling the back-gear of a lathe, to the axles of an ordinary standard horse car. The motor and gearing were suspended in a frame, one end of which was swung on one axle of the car and the other end attached to the platform. A friction clutch completed the outfit. The rails were bonded by driving soft iron horseshoe nails between the rails and fish-plates at the joints. A variety of trolleys, some of them supported by poles, were tested and finally a trolley wheel running on the top of the suspended overhead wire and

dragged behind the car by means of a cable was adopted. The generator was a 12-light arc machine, series wound, and the voltage employed ran up to several hundred volts on occasion. The line had grades up to seven per cent and was operated very successfully. Somewhat later an open car of the same general construction was put in service and this was occasionally used to haul freight cars. Speeds as high as 20 miles an hour were attained.

All of the roads constructed up to this time were practically experimental, but in the Spring of 1885, the Baltimore Union Passenger Railway Company, of Baltimore, Md., contracted with Mr. Daft for the equipment of a suburban branch of its system, running about three miles out of town to the village of Hampden, with a third-rail electric system. The line had grades up to seven per cent and exceedingly sharp curves, some of them of only 50 feet radius. A 25-pound iron T-rail was laid between the running rails on insulators consisting of cast-iron bells bushed with hard fibre. On each side of this rail wooden stringers, four by four inches, were laid to guard against accidental contact with it and a difference of potential of 125 volts was maintained between this rail and the running tracks by means of two dynamos of a Gramme-ring type, each of about 20 kilowatts capacity. Locomotives were employed to haul standard one-horse or "bob-tail" cars. These were equipped each with one motor of eight horse-power, the motor having a wrought-iron field of the Siemens type, with consequent poles and a Gramme-ring armature, and weighing about 1,000 pounds. It was connected through a single reduction gearing, consisting of a three-inch phosphor-bronze pinion and a 27-inch steel counter-gear, to one axle. The total weight of the locomotive was a little in excess of two tons. Regulation was accomplished by commuting the field windings, three speeds being obtained in this way. The road was opened August 8, 1885, with four locomotives. At the numerous road crossings the third rail was omitted and the current was fed to the cars by means of a three-quarter inch iron gas-pipe supported on bracket arms from poles at the roadside, contact with this being made by means of a sheet-copper brush pressed up against the under side of the gas pipe by a trolley which could be thrown into position by levers from the inside of the locomotive. Crude as this equipment was as compared with modern installations, it proved satisfactory and was operated for several years without serious accident or delay.

About the same time that the Baltimore line was put up into operation Mr. Van Depoele constructed a short line at Toronto, Ontario, using one motor car, which hauled three trail cars, and equipped with an overhead wire, on the under side of which ran a collecting brush.

In December, 1885, Mr. F. J. Sprague read before the American Institute of Electrical Engineers his classical paper on the "Electrical Equipment of the New York Elevated Railways." In the early part of the next year Mr. Sprague began his experimental work on the Thirty-fourth street branch of the elevated system



STEPHEN D. FIELD.

developing there what we now recognize as a practical system, but which was, unfortunately, a little too far advanced for its period. During that year and the following he worked diligently at the problem presented in electric railway work, and invented the method of suspending a motor from the axle of the car and a spring, so that its armature shaft would remain at a constant distance from the car axle. The first motors constructed for the St. Joseph, Mo., line, which was built early in 1888, were of single reduction gear pattern, but this was shortly discarded in favor of a double reduction gearing. In 1891 perfection in the design and manufacture of motors had proceeded so far that the single reduction gear was again possible, and it has been in use constantly since that time.

In the Spring of 1887, the Union Passenger Railway Company, of Richmond, Va., with a spirit of enterprise that can not be too highly commended, entered into a contract with Mr. Sprague for the equipment of its new lines, then building. These were 13 miles long and it was intended to operate from 20 to 30 cars upon them. Work began early in 1888 and was carried to a brilliant and successful conclusion under Mr. Sprague's personal supervision and by dint of almost colossal labor, night and day, on the part of that gentleman and his assistants. The power-house contained six 40-kilowatt 500-volt Edison bipolar generators, driven by three 125-horse-power Armington & Sims high-speed engines. It is interesting to note that several of the old generators are still at work, some of them being used in pairs—one as a motor and the other as a dynamo—for boosting a feeder supplying an outlying section of the system.

It is also interesting to note at this point the status of electric railways in the United States at this period. On January 1, 1888, there were thirteen electric railways in the United States and Canada. Upon them was operated a total of ninety-five motor cars and they comprised among them forty-eight miles of track. Of these various roads, six were of the Van Depoele system, three of the Daft system and one each of the Fisher, Short, Henry and Sprague types.

The success of the Richmond installation was the one thing necessary to stimulate both capitalists and inventors to the most active interest in electric railway matters. In 1889 the Thomson-Houston Company acquired the patents of Bentley & Knight and of Van Depoele. In 1890 the Edison General Electric Company took over the Sprague Electric Railway and Motor Company and acquired the patents of the latter, and for several years these two were strong competitors in the railway field. In 1891 came the historic litigation between the telephone companies and the electric railway companies, caused by the latter interfering with the grounded circuits of the former. In the January term of that year, in the Supreme Court of Ohio, at Cincinnati, a decision was rendered that the telephone companies had no paramount rights to the use of the earth as a conductor and the matter was thus definitely settled.

Meanwhile, in Europe, electric railway building had been going on, though haltingly as compared with its great extension in the United States. In Budapest, Austria, Messrs. Siemens & Halske opened, in July, 1889, a conduit railway of considerable size. A conduit directly under one of the rails was used and for the first time concrete construction was attempted in conduit work. This railway had grades of fifteen per cent and many

curves, one of them on the steepest grade. The road went into operation with nearly fifty cars and has been in continuous and successful commercial use ever since. It was the first successful conduit railway.

It may be proper at this point to speak of the numerous closed-conduit systems that have been exploited abroad and in the United States in the last twelve years. In general these consist of a subdivided or sectional working conductor laid on the surface of the ground and connected with buried feeders only at the time when the car is over them. This connection has been made by a large variety of mechanical, magnetic and electromechanical devices, more than two hundred patents for such systems having been granted by the United States Patent Office alone. With the possible exception of the Diatto system, now at work in Paris, and the system of the Westinghouse company, in operation at Monte Carlo and at the Indian Head Naval Proving Grounds, on the Potomac River, there are none of these systems in practical operation. It seems likely, however, that a considerable success will be attained with such systems within the next few years, as they are free from the objections frequently urged by municipalities against the overhead system, and are less expensive in installation than the modern open-slot conduit which is described below.

Numerous sporadic attempts have been made in the United States and elsewhere to operate electric railway cars by means of accumulators carried in them. Perhaps the most elaborate and conclusive experiment of this variety was that attempted on Madison avenue, in New York city, during the year 1890. Fourteen cars were used, running between the Post Office and a charging station at the car stables in Eighty-eighth street—a total distance of about five miles. In order to carry out this experiment new tracks of a heavy girder type were laid over the entire line and elaborate apparatus for charging and handling accumulators were installed at the car barns. The motors employed were of the Reckenzaun type and 110 cells of accumulator were installed on each car in two long boxes, fifty-five cells in each under the side-seats of the cars. The cells were of the Julien type containing pasted plates, and every care was taken to give the system a thorough and satisfactory test. Up to December 1 of that year the cars had made an average of about six thousand miles each, sufficient to demonstrate that the system was, at that time, impracticable. The high depreciation of the batteries seemed irremediable and the experiment was abandoned after about one year of trial. Several other lines have been operated since in various portions of the country, the Thirty-fourth street crosstown system, in New York city, being now equipped with accumulator cars—the only such line in the United States at present.

CHARLES J. VAN DEPOELE.

Mr. Sprague's experiments on the elevated railway were probably the first attempts at heavy electric traction, by which term is meant the operation of cars larger

LEO DAFT.

than those in use ordinarily on street railways. In 1888 and 1889 Mr. Daft equipped about two miles of the Ninth avenue division of the New York elevated railways and operated upon them an electric locomotive of large power. He succeeded in making speeds as high as forty miles an hour with six heavily loaded cars, and from the electrical point of view the system installed by him was a remarkable success. During all the period of its operation, extending over many months, the electric train was run in between the steam trains in regular service and not once was one of the latter ever delayed by any breakdown of the electrical outfit. The time was not ripe, however, for such a revolutionary innovation as electric traction on a large scale and the project was allowed to lapse. Perhaps the next important work in this direction was undertaken in 1895, when the Baltimore & Ohio Railroad excavated a long tunnel under the city of Baltimore. Municipal ordinances did not permit the ventilation of this tunnel by openings in the streets and it was clearly seen that it would be impossible to operate heavy trains through it with steam locomotives. The General Electric Company constructed for the service of this tunnel three locomotives, each weighing 92 tons and developing 1,000 horse-power, after general designs by Dr. Louis Duncan. An overhead system of supply was used, the working conductor consisting of a pair of steel channel beams supported from chains swung between structural steel towers. With these powerful motors, passenger and freight trains, locomotive and all, were hauled at high rates of speed through the tunnel and up a grade of 1.57 per cent at its northern end. The system is still in use and has given general satisfaction to the management of the railroad company.

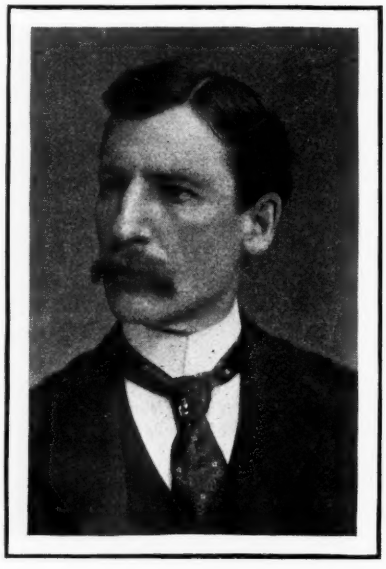
Following this, experiments were made by the New York, New Haven & Hartford Railroad Company upon high-speed and heavy-service trains on a division of the road running in the suburban district of Boston, Mass., to Nantasket Beach, and later upon the main-line division of the railway connecting the towns of Berlin, New Britain, Meriden and the city of Hartford, in Connecticut. In the former installation an overhead system was used, and in the latter a third-rail conducting system of great simplicity was laid down. Upon the ties, between the running rails, were placed at intervals of four or five feet insulators consisting of hardwood blocks saturated in paraffine. Upon these the third rail was laid, resting upon them solely by its own weight. This rail consists of an A-shaped section, weighing 100 pounds to the running yard, and made in thirty-foot lengths, heavily bonded at the joints. Its form is such as to divert rain and other moisture away from the insulators, and it is stated that even in snow and in wet weather, the insulation of the

line has remained satisfactory. A potential difference of about 600 volts is kept up between the third rail and the running rails, which are used as the return conductor. Upon this section regular passenger trains are hauled by motors developing 700 horse-power, attached to the trucks of one car. A very similar installation was placed, in the year 1898, upon the Brooklyn Bridge, connecting the Boroughs of Manhattan and Brooklyn in New York city, and at present the electrical equipment of the entire elevated system in New York city with a third-rail system is under construction.

In the Summer of 1900 the Central London Underground Railway, running between the Bank and Shepherd's Bush, in the city of London, was opened, a third-rail system, similar to that in use on the Brooklyn Bridge, being installed and electric locomotives of American make being used throughout. The City & South London Underground Railroad, in London, was equipped, in 1894, with an electric system using also a third-rail conductor and operating motors directly upon the axles of the locomotive. This system is still in use and has given highly satisfactory results, especially as concerns the comfort of passengers and the purity of the air in the tunnels.

Coincident with the great extension of the electric railway motors, control methods, trolleys and all other portions of the system were rapidly developed. In the Richmond road, which may be taken as a prototype of the modern trolley railway, the windings and commutators of the motors were exposed to the dust and dirt and moisture of the streets with the results that accidents were common and the rate of depreciation of the electrical machinery exceedingly high. In 1891, with the design of the four-pole motor adapted to single reduction gearing, efforts were made to produce enclosed types of street railway motors and within a year or two motors of the practically perfected type still in use had been brought out. The modern street railway motor has its frame made in two parts, each carrying two of the four poles of its field and forming, when bolted together, a completely enclosed structure. In the early cars the gearing was exposed to dust and rapidly wore out, but in later types all of the running portion of the gearing is enclosed in tight metal casings which are filled with oil, thus contributing both to the life and the quietness of this important portion of the car's mechanism. In 1890 the Westinghouse Electric and Manufacturing Company, of Pittsburgh, Pa., entered the street railway field as a rival of the consolidated Thomson-Houston and Edison interests. The competition between these two great corporations was sharp and keen, and doubtless hastened in no small measure the development of the perfected street railway apparatus of to-day. For a considerable time there was a dispute between the adherents of single-motor and two-motor equipment of street cars, and both commuted field and series-parallel connection methods of control had their partisans.

To-day, both through the expiration of numerous patents and the consolidation of manufacturing interests, the equipment of street railway cars has become almost entirely standardized in the United States, a combination of the series-parallel and the commuted field regulation being in use. Platform controllers for electric cars have



FRANK J. SPRAGUE.

been developed, through many stages, to high perfection. While it is necessary, in them, to handle heavy currents and often to break down some hundreds of amperes under 500 volts pressure, the use of the magnetic blowout system has reduced the wear of contact surfaces to a minimum. It may be justly claimed to-day that the depreciation of electric railway rolling stock and motive power apparatus is as small as that of any other hard working machinery.

The choice of 500 volts as the working pressure on the Richmond railroad seems to have made that figure a favorite among American railway engineers. It has become during the last 10 years the standard voltage for traction purposes.

With the growth and extension of street railway systems in our largest cities, and especially with their consolidation, there came frequently the necessity for operating sections of roads far distant from the power-house, with the moderate pressure of only 500 volts delivered at the trolley wire. It was necessary to devise some system for saving copper and for permitting the working of such lines from a distant power station. To this end, as a first rough and ready suggestion, the booster was devised. This machine consists of an auxiliary dynamo, driven either by an independent prime-mover, such as a steam engine, or by an electric motor; through it the current of a particular feeder passes and receives an increment of voltage. While, in a way, answering the purpose, the booster in no way contributed to reduce the considerable losses of current encountered in long transmission. The second system which is in use largely throughout the country at present is that of distribution from the central station by means of high-tension polyphase currents received at conveniently situated substations and in them transformed in voltage and converted, through synchronous converters, into direct current of the proper pressure. Nearly all of the systems so far installed have used a three-phase system of supply generated directly at from 5,000 to 10,000 volts at the dynamo and suitably converted at substations. The magnificent equipment of the Metropolitan Street Railway Company, of New York city, is a fine example of this variety of power distribution.

In 1895, in Washington, D. C., the first complete system of conduit railways was installed in the United States. This was shortly followed by lines of an almost identical character in New York, in which city are now in operation 100 miles of conduit railroad. The construction of these conduits has, like everything else pertaining to electric traction in the United States, become practically standardized. The running rails of the track are supported on cast-iron yokes spaced five feet apart, and also supporting at their middles the two Z-shaped rails forming the jaws of the open slot. The conduit proper is moulded in concrete upon these yokes, and carries as working conductors two T or channel beams of steel, connected at proper intervals to heavy copper feeders laid in conduits alongside. Current is taken by means of a plough—a device resembling a shuttle in appearance and carrying contact springs on its two sides rubbing against the parallel faces of the working conductors. In these roads the track is not used as part of the electrical conducting systems, both polarities of the current are carried in the conduit on the working conductor.

The latest development, and in some ways the most promising application of electric traction, has been made in Europe in the installation of railways operating directly with polyphase currents. Among these perhaps the most important examples are the extraordinary railroad running up the Jungfrau and the line between Lecco and Chiavenna, in Italy. In the former a difference of potential of about 500 volts is maintained in each phase of the supply current delivered to the motors. These are of the induction type and are regulated by the insertion of resistance in their secondary circuits. In the Italian road the line voltage of 10,000 volts is delivered directly to the trolley wires, two in number, and is received directly in the primary of the motor on the locomotive.

Electromobile Evolution.

By W. H. Maxwell, Jr.

AS WE STAND on the brink of the new century and marvel at the progress made in the construction of the electric automobile during the past two years, it seems that the time is ripe to take stock of what really has been accomplished. New resolutions, not to be broken, will find many excuses for being, and it is to be hoped that they may be made in order that lasting good may be done the electric automobile industry. When we speak of an industry we obtain the idea of an established business or occupation which is commercially solid, and which is the support of the hundreds engaged in its advancement. I believe we have a right to say that those now building electric automobiles are factors in a colossal industry, and that the time of experimenting has long since passed by.

From the very first, when the means of harnessing electricity and applying it to man's uses were discovered, the adaptability of that power for use in the automobile was instantly recognized. Given an adequate supply of electricity, nothing can be better than the electric motor for the propulsion of vehicles. Cleanliness, combined with ease in management and operation has tended to draw the services of the best electrical engineers in the world to the solution of the many vexing problems which have blocked the way of the perfect electric motor vehicle.

The greatest strides in the advancement of the industry have, without doubt, been made in the last two years, and that right here in these United States. This great progress has been made by the carrying out of a system, unrecognized by many, but still a system developed along the natural lines of least resistance. Those engineers who gave themselves up to the development of the electric automobile found that they could use to great advantage the experience they had gained in their work on the trolley and electric lighting systems. Because of the small load and its readiness, in a physical way, for the adaptation of a motor, the light vehicle for two passengers has reached the highest stage of advancement.

The greatest improvements have been made in the simplification and lightening of the transmission gear and of the vehicle itself. Indeed, it is safe to say that all absolutely required in the domain of mechanical engineering and carriage building has been accomplished. The last two years have been so productive that the earlier experiments made by Jeantaud, Immisch, Carli, Ward, Clubbe, Volk and others of equal note need not be considered here. All have been surpassed in the years of ninety-eight, ninety-nine and nineteen hundred.

Experiments without end have been made, and the final result is that we now are well assured of what can and can not be done with and by the electric motor vehicle. As a broad proposition, since its value is to finally rest on the comparison, it is now a demonstrated fact that an electric automobile will do more than a horse, and can be used wherever a horse-drawn vehicle can be reasonably expected to operate.

On what does the value of the electric vehicle depend? Other means of transportation such as the steam railroad, the trolley and the horse have made the entering wedge for the automobile. To such an extent is this so that the demand is now always present and does not need "working up" to any great extent. The nature of this demand is to be judged from a business point of view both in the commercial world and in the domestic domain.

In just what fields is the electric motor vehicle suited for use at the present time? We saw them used first of all as private pleasure vehicles. Then the public cab designed to carry about the same load was tested on our streets. How soon they demonstrated their superiority over the horse in this line of work is a matter of history. Next the more venturesome spirits set themselves to work to evolve a practical motor omnibus with a carrying capacity varying from eight to twenty persons. Even the huge abyss between the two-passenger and the twenty-passenger vehicle was safely crossed by the electric automobile.

W. H. Maxwell, Jr., was born in Brooklyn, N. Y., and graduated at the Brooklyn Polytechnic Institute and Columbia University. Since leaving college Mr. Maxwell has been closely connected with the automobile industry, now being a member of the engineering corps of the American Vehicle Company. Mr. Maxwell has had exceptional opportunities to study and compare various types of electric automobile vehicles and is recognized as peculiarly competent to speak of the present status of the art with which he is closely identified.

The large department stores in New York, Chicago, Boston and Philadelphia, many of which employ anywhere from 50 to 300 horse wagons of all kinds in their delivery departments, began to cast longing eyes toward the motor vehicle. So long as they ignored their account books the expenditures necessary to maintain their enormous delivery services did not seem so great. When, however, a few energetic pioneers in the field of electric vehicle transportation induced them to sit down with paper and pencil and find out really what they were paying for their respective delivery services, it was not long before electric delivery wagons made an appearance on the streets.

Why was it that these hard-headed conservative men were so quick to adopt the electric motor delivery wagon in their business? Simply because the electric motor vehicle *is* cheaper to operate than the same style of wagon drawn by a horse. It has been demonstrated, time and time again, that an electric delivery wagon will do twice the work in a given time of a similar vehicle drawn by animal power. The cost for power is insignificant. The wages of the operator, simply as such, need be no higher than that now paid a man to direct the movements of a horse vehicle, because, in direct contradistinction to the steam-driven vehicle, no great amount of mechanical skill is required in the operation or care of the wagon. The same applies to a vehicle driven by an internal combustion engine. For these reasons, which govern every use to which a horse or mechanically driven vehicle can be put, the electric automobile holds first place. It is cheaper, cleaner and easier to operate than any other system, excepting none.

In all these comparisons as to cost we must take note of the original investment and the expense of maintenance of each system compared. The motor vehicle will appeal to two classes: those to whom the matter of expense is nothing; and those who purchase because they believe they are making a good investment. In making this financial estimate the only way to arrive at a correct conclusion is to consider only the earning capacity of the vehicle. While the original outlay is undoubtedly large, the saving, because of the vehicle's increased capacity for work, is extremely great. The original outlay should not be considered further than to charge off the interest on the investment

at 6 per cent, and 15 per cent for depreciation.

Take, for instance, the work done by a horse-drawn wagon in the delivery service of one of our large department stores in New York city. The manager stated to the writer that he operated one-horse vehicle from his store to Fifty-ninth street, and another from 59th street to Seventy-second street. Each day at the present time one electric delivery wagon makes the whole trip twice at least from the store in question to Seventy-second street. To do the same work with animal power four horses and two men are required. Making the comparison on the basis of the work done, there is no doubt but that the result will greatly favor the electric vehicle, original outlay and all other charges being duly considered.

What relation does the care of the vehicle bear to its cost of operation? Nothing need be said here, except that those who use common sense in the care of their apparatus get the results which accrue from such a course, and those who don't deserve all the vexation which, without fail, falls to their lot. Such vexation, while annoying, is also expensive, and the careless operator or owner of an electric automobile made by a first-class manufacturer has only himself to blame for his troubles.

Many times do we hear the opinion expressed by various well-informed people, who are usually in the same glorious condition in regard to every topic you can bring up, that the automobile as an industry is good for about five years and at the end of that time we will all have vehicles presented to us as gifts, or we will be so tired of them that we won't accept such a present. All these oracular remarks presuppose the fact that an automobile is purchased as a novelty. Nothing can be further from the case of the electric automobile. For quite a number of years past we have been using horse-drawn vehicles to transport ourselves and our chattels from place to place. We now demand the same elegance and capability for service from the automobile that we did from the horse vehicle of a similar type. Two or three years ago such a demand would have been laughed at. Our engineers were then busy in perfecting the mechanical features of their vehicles, and neglected the artistic side almost entirely. What a change a short space of time has worked! We no longer see in the latest types of cab or coupé a hideous black box stuck on the rear of what has the appearance of being a house carpenter's creation. The greater number of the mechanical problems as to motors, gears, etc., have been solved, and we have vehicles that are shapely, superbly colored and upholstered. For elegance and beauty and originality of design the electric vehicle has already taken the palm from the hitherto existing types, no matter what the style of carriage, or the use to which the vehicle is to be put.

The great aim of the electric vehicle manufacturer during the past two years has been to get away as far as possible from the so-called "bicycle construction." Tubular frames and wire wheels are being gradually discarded. Regulation carriage hardware of the best grade has been used so as to allow any good carriage manufacturer to make necessary repairs. In this way excessive freight charges for the transportation of the vehicle to the factory are avoided.

The old idea that a particular kind of frame is necessary for the electric motor vehicle is being rapidly dissipated, and the running gears are now being attached directly to the vehicle bodies which are usually built on channel irons. This has given the bodymaker an opportunity to find a place to put his batteries where they will attract the least notice.

The question of tires is one that is causing much trouble to all vehicle manufacturers. It is a mooted question as to whether the pneumatic or the solid tire gives the best results. One authority advises the use of the pneumatic, and another will not equip his vehicles with anything but the solid tire. There is no question but that a carriage or wagon properly hung on the springs needs little else to prevent its being jarred to such an extent as to impair its usefulness. The pneumatic tire has not been used to any great extent, except on pleasure vehicles, as the cost for maintenance on a delivery wagon would prohibit its use.

No rubber tire has been discovered as yet which will not slip on the wet asphalt pavements of our streets. This is the most vexing problem which the tire manufacturers have to solve. When they arrive at a correct solution the result will mean increased mileage for the electric vehicle.

In the matter of storage batteries we find the problem which has bothered the electric vehicle manufacturer more than any other. Phenomenal advances have been made in lightening the weight of the cells and increasing their capacity. Indeed, the battery makers have brought their product to such a stage of perfection as to the distance which they will drive an electric vehicle on one charge, that they are now devoting most of their energy to increasing the life of the cells. For the majority of people 35 or 40 miles is sufficient for a day's riding, and it is more than ample for a commercial wagon. To make a battery which can be put in the hands of any novice, and which will stand the inconsiderate use given it by such a person, is the goal for which every electric vehicle manufacturer is striving. They must be made to charge and discharge rapidly without disintegrating to any appreciable extent.

As for the power supply, the user or owner of an electric automobile has to thank the good fellowship which exists among those in the electrical fraternity. Almost without exception the producers of electrical power have offered great inducements to the prospective users of automobiles in the way of supplying power so as to get the electric motor vehicle in use. You can go to the smallest town where there is an electric lighting plant, and the managers of it will do all in their power to provide the necessary facilities for charging. To such an extent is this so that in one large city, which the writer visited recently, the electric lighting company has made a standing offer for the coming year to provide the necessary power gratis to every user of an electric automobile.

In addition to these facilities our automobile clubs are making strenuous efforts to have "electrants" introduced where possible. Many of the suburban hotels in the vicinity of the large cities have installed charging plants, and it is thus possible to make extensive trips into the country. In many instances it is now possible to make tours of hundreds of miles, as charging stations have been established all along the more frequented routes.

A number of manufacturers recently decided to standardize as many parts of their vehicles as possible. They started off by equipping their vehicles with the same size charging plug. The battery boxes are to be made to a standard which will allow of them being easily interchanged. In making an extended trip it will thus be possible for a motorist to leave his batteries at a station and take up others already charged. That this method of operating electric vehicles will soon be in vogue there can be no doubt. When in full operation the only good argument the opponents of the electric vehicle have ever been able to produce will be placed *hors de combat.*

Some persons prefer two motors, and others one, to operate their vehicles. It has been the experience of the writer that one well-constructed motor does away with

much annoyance. The parts in the single motor are less liable to get out of order than when two motors are used, for they are much larger, and so can be more firmly fastened. Of course the use of two motors does away with the necessity of a differential, but if that mechanism is well made it gives little or no trouble. If, however, the vehicle is so constructed that it is necessary to break the rear axle to insert the differential, the stability of the wagon is sure to be greatly diminished. The gearing which seems to have given the best results is in the cases where the differential is contained in a hollow armatured motor, the pinions being attached to the motor shaft, which is broken, instead of to the rear axle.

The most progressive manufacturers have not tried as yet to come to any definite course in regard to the number of motors they use. For some work they use one and for other work two. The single motor has, however, given the best results. In cases where the "bicycle construction" has been used in the frame the double motors have been known to throw the whole gearing out of alignment.

In regard to the regulation of the speed control, the most approved method seems to be to use both the batteries and the field. The compactness with which the controlling mechanism is arranged is the direct result of the experiments and experience of the last two years.

The gears themselves have given the best results when the pinions are made of rawhide. Steel, throughout the whole of the running gear, is the only safe metal to use.

Band brakes applied to the gears, and electric brakes obtained by reversing the motor at a low rate, are the only safe methods to use in stopping an electric vehicle. An emergency brake to operate on the tires is sometimes used, but it destroys them so rapidly that this method is not employed to any great extent.

The steering gear should be made strongly and of the best material obtainable. It matters little whether it be operated by a lever or a handle, as almost every well made electric vehicle is now fitted with a substantial equipment for turning the wagon. Here the question of turning with the rear or front wheels comes in. Almost without exception the majority of manufacturers steer their vehicles with the forward wheels. Some of the cabs now being operated on our city streets have their steering apparatus applied to the rear wheels. It is, however, somewhat more awkward than the way a vehicle is usually turned and the system has not been extensively adopted. Many considerations as to whether the load should be pushed or hauled, might be here taken up for review, but is a question of expediency as much as mechanics in the case of the electric vehicle

More capital has been invested in the construction of electric automobiles than in any other branch of the motor-car industry. Modern business methods, it must be regretted, seem to lay down the rule that for every dollar paid into the treasury of a corporation, several must be issued in stock. This system of inflation has been the bane of the automobile industry. Schemers of no responsibility have foisted valueless securities on a too ready public, and those concerns which deserve the support of everyone do not get it. Where sufficient capital to do the business mapped out is paid into a company treasury, and where men of sterling integrity are behind the project, the matter of overcapitalizing a corporation does not amount to much. Where, however, a company of say, five millions capital, with just enough paid in to turn out a few vehicles, tries to pose before automobile buyers as a reputable concern, it should be exposed. First of all, its securities of necessity can have no value. Secondly, it is so liable to failure that any repair parts needed in the future can be obtained only with great difficulty. As a matter of fact the vehicles turned out by this class of manufacturers need more repairs than others.

Two years ago we heard of the great boom that was sure to take place in automobile stocks. A majority of those companies are now either defunct or forgotten. The industry has struck its stride, and has settled down to a business basis. Charles R. Flint, the well known New York capitalist, recently said, in part, after having made a most minute examination of the whole field from an investment point of view: "A great many of the companies that have been formed have issued stock which represents little more than the capitalized hopes of the projectors. In my opinion the automobile business has reached a point where it will be transacted on its merits." Such a statement as this from a man of Mr. Flint's great experience, can only mean that those companies which are not trying to do business on their merits can wind up their affairs in but one way. More capital will be placed in the companies now organized, and in others to be formed in the future great care must be taken by the prospective investor to see just where he is going, for the automobile field has been a veritable harvest for unprincipled schemers and blackmailers. What with companies organized simply to place stock, and with others formed for the sole purpose of being bought out by their more successful rivals, little can be hoped for by the "dear public" other than to be made the victims of these highway robbers. The dozen or more concerns doing a legitimate business deserve the popular support; those behind the other concerns deserve popular support, furnished, however, in a different way.

Quoting Mr. Flint again, he says, speaking of the outlook for the automobile industry as a business: "There can be no doubt than an enormous business is going to be done, not only in the manufacture of vehicles for pleasure purposes, but also in motor trucks, delivery wagons, and other vehicles of commerce. Competent authorities estimate that during the next five years the great sum of $100,000,000 will be expended by purchasers of automobiles." There is no question but that the large bulk of this business will go to the electric vehicle. It will only go to it, however, when the prospective purchaser has learned to rely on the representations of the manufacturer. No industry ever before had the public welcome it so warmly from the very start. It is too bad that the proverbial black sheep should be in the fold of the electric vehicle manufacturers. Their misrepresentations have done more to set the business back than anything else could. After leading the purchaser to suppose the vehicle will make twice the mileage for which it was built, they refuse to stand back of their statements when the time for complaints has arrived.

There is not the slightest excuse for delays in delivering vehicles. The best concerns have their organizations perfected, and any one who gives his order to those not suitably equipped should not complain when he is put off with the excuse that "the varnish didn't dry as quickly as we thought."

Don't buy any vehicle unless from a well known and reputable company backed by well known, responsible men. Try your vehicle and see that it does all its makers claim, and if you order from reliable concerns you will find them ever ready to live up to their agreement to the last letter.

In conclusion: The electric motor vehicle stands to-day first and foremost in the whole automobile field. It is practical for every use to which mankind is ever likely reasonably to put it. It is not an experiment, but a tried and successful actuality. It is the easiest type of mechanically driven vehicle to operate. It needs but little care, and if given that little regularly, will render better service than is obtainable under any other conditions. Two years have made the electric vehicle what it is, and have drawn the most skilled engineers in the country to its development. Two years more should give us the perfect storage battery, and then—well, just *then*.

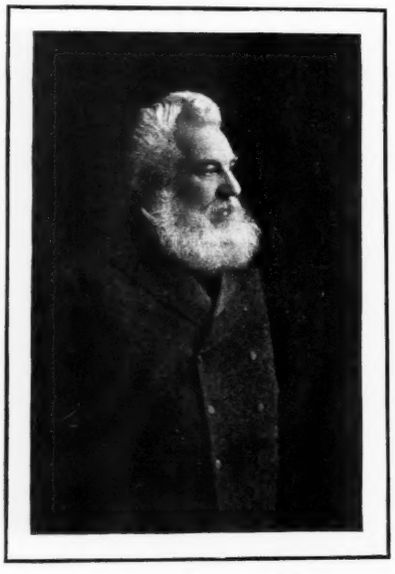
The History of the Invention and Development of the Speaking Telephone.

By Geo. C. Maynard.

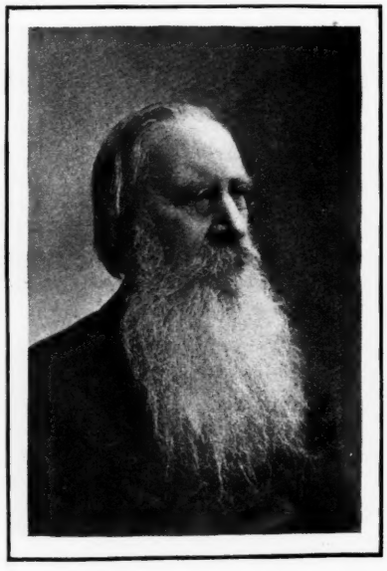
"My God! it does speak!"—and all the peoples of the earth are listening to its voice speaking in their own familiar tongue.

THE INVENTION.

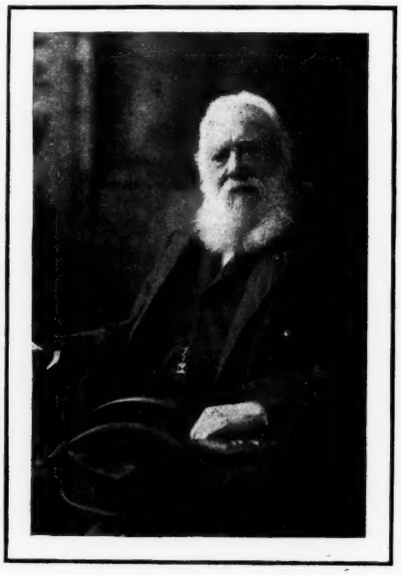
In the whole range of wonderful inventions which have made the nineteenth century famous, none is so full of continued interest, so fascinating, mysterious, so nearly supernatural, as the speaking telephone, for the production of which the verdict of the world has given Alexander Graham Bell the rightful credit. And no other invention of the century has proved so practically useful, and so universally applicable to the needs of humanity.



ALEXANDER GRAHAM BELL.
Inventor of the Telephone.



GARDINER G. HUBBARD.
The Pioneer Advocate of the Telephone.



ALEXANDER MELVILLE BELL—1901.
Father of Alexander Graham Bell.

By many persons the invention of such a marvel is regarded as the result of a sudden inspiration of genius, finished and ready for the use of an age prepared to receive and utilize it, and they fail to appreciate the great skill, labor and patience which are often required to put an invention into practical use. This was especially the case with the telephone. No invention was ever more clearly the direct result of intelligent comprehension of the subject and of long and thorough study and experiment, coupled with inventive genius of a high order, than Bell's invention of the telephone which embraced not only the details of perfect construction of the apparatus, but the discovery and application of the underlying principles on which every successful telephone has been made.

IN THE PATENT OFFICE.

Early on the morning of February 14, 1876, Bell's application for a patent on his invention, which had been carefully prepared months before was filed in the United States Patent Office. On the afternoon of that day the attorney for Elisha Gray sent to the Patent Office the amount of money required as a fee for filing a caveat, which, at that time, had not been written. The document was hastily prepared and rushed to the Patent Office just before the Department closed on that day. Gray's caveat did not describe an invention but gave an indefinite explanation of what he hoped to invent. In the ensuing controversy, growing out of interference proceedings, and culminating in bitter legal battles and much newspaper discussion, it has often been stated that Bell's application was granted through some irregular or dishonest action on the part of Major Z. F. Wilbur, the principal examiner who had charge of the telephone cases. The statement is not true. Wilbur was then, and thereafter continued to be, hostile to Bell, whose patent was issued in March, 1876. It is much to the credit of Mr. Gray that he recognized and publicly declared that Bell, and not himself, was the first inventor of the telephone.

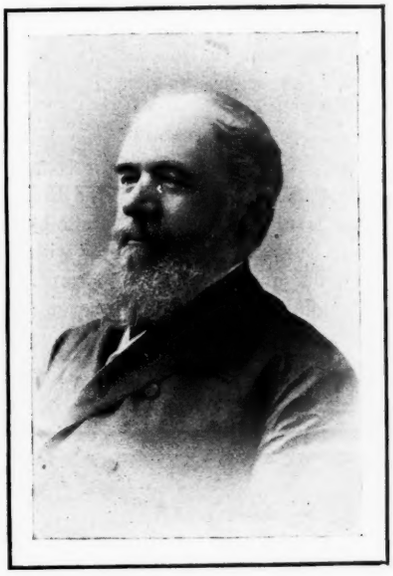
Mr. George C. Maynard at fifteen years of age was a telegraph operator on one of the first lines in Michigan. He was one of the early exploiters of the Western Union company and was cipher operator in the War Department at Washington during the Civil War. He organized the telegraphic system of the United States Weather Bureau, and organized and managed for several years the Washington, D. C., telephone exchange. He is now a consulting and supervising electrical engineer. He is a member of the American Institute of Electrical Engineers, a former president of the Old Time Telegraphers' Association, and is secretary of the Telegraphic Historical Society, and of the Association of American Inventors and Manufacturers.

ITS INTRODUCTION TO THE PUBLIC.

In June, 1876, Professor Bell was hastily called from Connecticut to the Centennial Exhibition, in Philadelphia, to meet Sir William Thomson and show him the new invention which was set up in an out-of-the-way gallery with no one to explain its workings. The distinguished English visitor placed the simple little wooden thing to his ear, listened a moment and dropped the instrument with the astonished exclamation quoted at the head of this account. Elisha Gray, whose telegraphic exhibit was conspicuously installed in one of the main buildings, was with Sir William at the time and was equally surprised. Following this memorable exhibition a few instruments were made and sent to various persons throughout the country. Those most interested were professors in schools and colleges, and other persons of a scientific turn of mind who desired to use the instruments to illustrate their lectures on physics, without having the least idea that they would ever be adapted to commercial use.

Early in 1877 the telephones, having been tested sufficiently to prove their practical utility, were brought to the attention of business men as a means of communication over short private lines but the proposition found little encouragement.

It now seems incredible that men who now use the instrument continually and who find it an absolute necessity first received the suggestion of its usefulness with skepticism and ridicule, and that it required the greatest effort to induce a few persons to even give it a trial. Bankers said it might, possibly, do for the grocers, but declared it could never be used in financial transactions; grocers were positive they could never safely receive an order for goods by telephone and referred to the liverymen as possible patrons of the

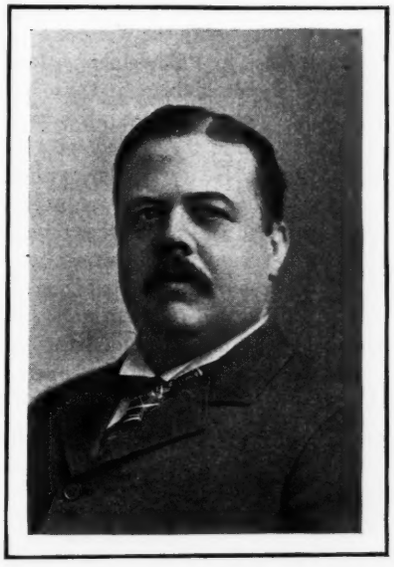


GEORGE W. BALCH.

humbug; an occasional liveryman was willing to give it a trial, but saw no probability of making its use profitable. At the outset it was expected that the telegraph fraternity would recognize the telephone, as in some degree, allied to their profession and give their aid to its introduction, but nine out of every ten operators in the country declared in one breath that it was utterly impracticable and, in the next, that it would ruin their business if not promptly suppressed.

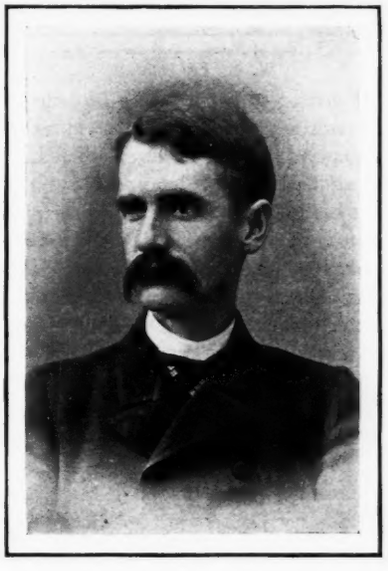
In the middle of August, 1877, the president of the Western Union Telegraph Company and Theodore N. Vail sat down together to examine the telephone and witness its operation. After the experiments were concluded the telegraph official declared in the most emphatic manner, that the telephone could *"never be of any practical use in business affairs."* Mr. Vail said nothing, but immediately made an engagement with Gardiner G. Hubbard to aid him in establishing and carrying on the business.

On August 25, 1877, Jay Gould had



CHARLES J. GLIDDEN.

his first introduction to the telephone by some friends who induced him to make a trip from New York to Washington to examine it, with a hint that "if he could see anything in it" there was a chance for him to buy it cheap. After an hour's critical inquiry into the matter, Mr. Gould left with such an air of skepticism and disgust that no man would ever have dared to mention the subject of pecuniary investment in the enterprise to him. The report that he was offered an interest in



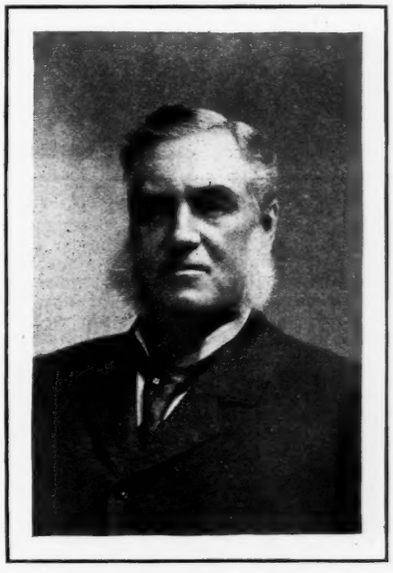
W. D. SARGENT.

the invention by Mr. Hubbard, or any one acting for him, is a fairy story. One of the amusing things connected with the subject is the fact there is a large and constantly increasing number of persons who are laboring under the hallucination that they might have made a great fortune by going into the business in its inception.

When Geo. W. Balch, a telegraph pioneer and one of the Western Union company's ablest superintendents, secured a perpetual telephone license for the entire state of Michigan, without paying a dollar for it, and went home with the document in his pocket, his associates in the great corporation laughed at him for "going into the toy business."

INTERESTING INCIDENTS OF THE EARLY DAYS.

The following news item published in a Washington paper September 27, 1877, throws a little side light on the telephone situation at that time:



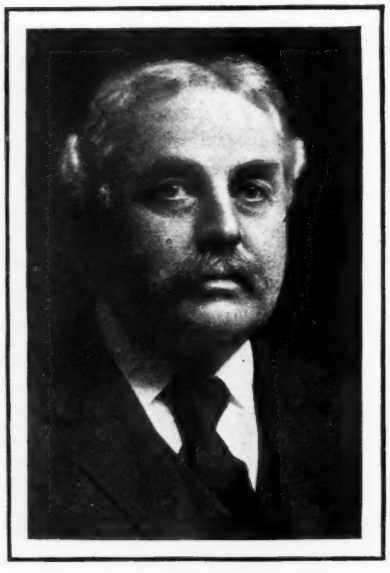
AUGUSTUS G. DAVIS.

"Everybody does not know that there are three telephones, and there is a great deal of confusion in regard to the matter. At a concert given by Maretzek in Lincoln Hall last Winter, Gray's telephone, or, as it is more commonly and properly called, Gray's 'harmonic telegraph,' was exhibited. This consists of a number of tuning forks, set in vibration by electromagnetic apparatus and connected to a telegraph wire, through which a powerful battery current is sent, having at the opposite end a number of sounding boxes to correspond with the tuning forks. Any note sounded by a tuning fork produces the same note in a sounding box and by this means simple tunes are played.

"Edison's telephone also requires strong battery currents and transmits musical tones, instrumental or vocal, but does not give the words of a song. The apparatus consists of delicate and complicated electrical appliances, large sounding boards, trains of clockwork, chemically prepared paper, etc. Both of these systems are used only for giving public entertainments.

"The speaking telephone, which is coming into general use, and about which so many wonderful things are told, is the invention of Professor A. G. Bell, of Boston. The instrument, which is no larger than a lady's toilet bottle, has at one end a mouthpiece, inside of which is a disk of sheet iron, two inches in diameter, and ten-thousandths of

an inch thick, firmly clamped in a wooden case and held about one thirty-second of an inch from the end of a permanent steel magnet, one-half inch in diameter and three inches long. At the end of the magnet is a small helix of wire, to which the telegraph wire is attached. The same instrument is used for 'sending' and 'receiving,' a person speaking in an ordinary tone of voice into the mouth-

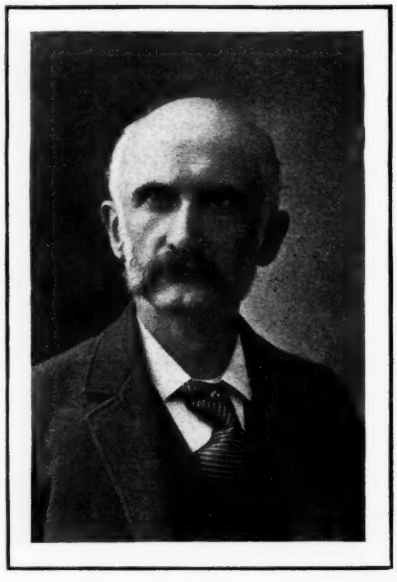


E. T. Gilliland.

piece, and then holding it to the ear to get the reply. Two of these simple pieces of apparatus constitute all that is required for holding conversation over wires hundreds of miles in length. No batteries are used, the permanent magnets furnishing all the necessary power. The explanation of these remarkable phenomena is that the sound of the voice produces vibrations of the iron plate which cause certain changes in the magnetic condition of the steel, which in turn develop currents of electricity in the wire. These currents—so exceedingly delicate that nothing but the telephone can detect them—flow through the line, and at the other end the operation is reversed, the same sound being produced, not only articulating every word clearly and distinctly, but giving every tone and expression of the voice, which can be recognized as readily as if the person speaking were beside the listener. Singing through the telephone is heard with a sweetness and softness that is marvelous and fascinating."

INTERESTING INCIDENT IN EARLY HISTORY.

On April 18, 1878, Professor Geo. F. Barker appeared before the National Academy of Sciences, of which he was a member, at a stated meeting held in the office of the president, Joseph Henry, in the Smithsonian Institution, in Washington, to introduce Thomas A. Edison and exhibit his carbon telephone. Among the distinguished scientists present were Joseph Henry, Benjamin Pierce, Wolcott Gibbs, Spencer F. Baird, Arnold Guyot, C. F. Chandler, S. P. Langley, J. E. Hilgard, O. C. Marsh, Simon Newcomb, William B. Rogers, General Montgomery C. Meigs and other equally illustrious men. Professor Barker, in a most eloquent and laudatory speech, presented Edison to the Academy as the original and only inventor of a practical telephone, and then explained that he would show an experiment never before successfully attempted, by establishing telephonic communication over a single wire connecting the Smithsonian Institution with the Western Union Telegraph office in Philadelphia. James Merrihew, Morell Marean and Fred W. Royce were in charge of the wires in the Smithsonian, while the Philadelphia end was managed by Henry Bentley, with the assistance of the Western Union experts. A wire equipped with Morse telegraph instruments was used for directing the experiments. One wire was tried on the telephone circuit and failed to work satisfactorily; several other parallel wires were added until four or five were "bunched" to reduce the resistance, and the members



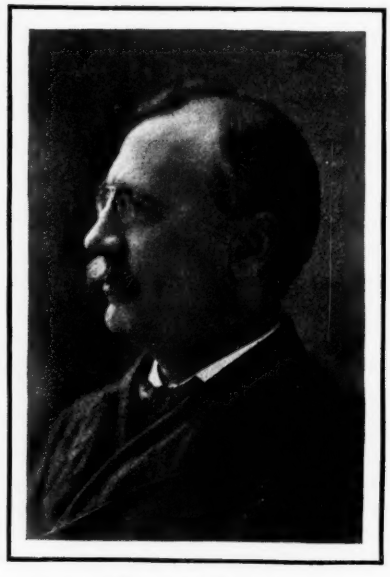
W. N. Estabrook.

were invited to listen to the Philadelphia conversation. Barker had a miscellaneous lot of Edison receivers and also a pair of Bell hand telephones that he had borrowed of Thomas E. Cornish for philosophical purposes. The latter were used throughout the exhibition. Six months before this event the representatives of the Bell company had held intelligible conversation over a single telegraph wire, on a stormy day, between Philadelphia and Washington with the ordinary magneto instruments.

ORGANIZATION AND DEVELOPMENT OF THE BUSINESS.

It was most fortunate, not only for the inventor but for every prospective telephone user, that the business was, at the outset, placed under the absolute control and management of Gardiner G. Hubbard, who foresaw, with a clearness that was prophetic, the possibilities of speaking communication in which distance should play no part.

For several years he controlled and directed the enterprise, avoiding entanglement with speculators, spurning suggestions of stock-jobbery, keeping before himself the single purpose of establishing a legitimate business on a broad and fair basis. He offered to the public not shares of stock in a scheme that might succeed or fail, but a serviceable system ready to do useful work for a reasonable compensation. Under his guidance the enterprise progressed, slowly but surely. The effort was not confined to this country. Bearing in his hand the simple telephone (faintly pleading with an incredulous world only to be heard) he crossed the seas and stood before rulers of kingdoms. The International, the Oriental and other companies were organized by Mr. Hubbard. He went to Russia, obtained important concessions, and was laughed at by some of his American associates when he proposed to commence business in that country. But he compelled the company to adopt his plan and to-day the Russian service is one of the most profitable of any in Europe. While dealing with international questions and important corporate affairs, Mr. Hubbard never overlooked or neglected the smallest details of the business. He was always ready to listen to the people who came to him with

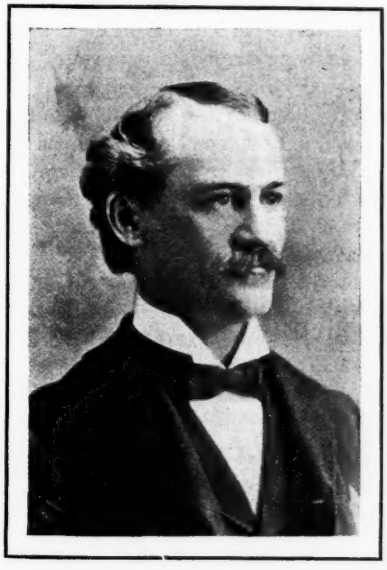


Morris F. Tyler.

numberless improvements and liberal advice. When two continents were breathlessly listening to hear the foot-falls of a house-fly on the microphones of Edison and Professor Hughes, he was quietly and carefully examining the crude apparatus of Berliner, in which he recognized the

elements of the only successful battery transmitter ever produced. He purchased the invention, directed the work required to complete and develop it, and made it of great value to the system.

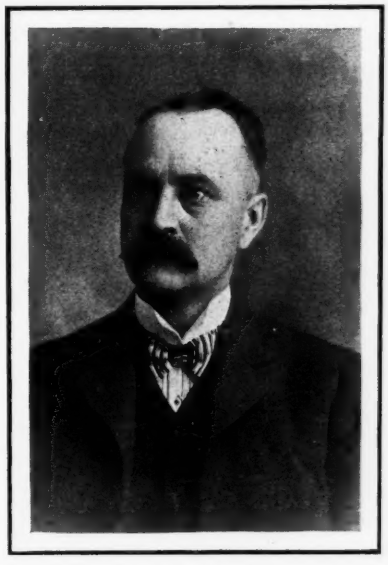
Mr. Hubbard started the business by



ELLIS B. BAKER.

appointing agents in the principal cities and granting licenses for terms of various lengths. Among the early agents and pioneers were C. J. Glidden, Lowell, Mass.; Thomas B. Doolittle, Bridgeport, Ct.; George W. Coy, Morris F. Tyler and E. B. Baker, New Haven; Thomas E. Cornish and William D. Sargent, Philadelphia; A. G. Davis, Baltimore; George C. Maynard, Washington; George W. Balch, Detroit; W. N. Estabrook, Elmira; George F. Durant, St. Louis; Edward J. Hall, Buffalo; Samuel Ivers, New Bedford; J. P. McKinstry, Cleveland; E. T. Gilliland, Indianapolis, and F. G. Daboll, Springfield, Mass.

The original Bell Telephone Company was organized with Gardiner G. Hubbard, trustee; Alexander Graham Bell, electrician, and Thomas A. Watson, superintendent. The headquarters of the company were at the electrical instrument factory of Charles Williams, No. 109 Court street, Boston. The company announced that "the speaking telephone of Professor Alexander Graham Bell has attained such simplicity and cheapness as to render it universally available for public, private, social or business communications. It enables the factory manufacturer to talk with the superintendent, the physician with his patients, establish instantaneous communication with the branch and main office, the home and the store or office, the country residence and the stable or any part of the ground, the mouth of the mine and its remotest workings." It was also stated that "conversation could be carried on between stations forty or fifty miles apart, if the wire connecting the telephone is not hung near those on which heavy battery currents are being used." The first telephone lease was issued June 8, 1877. By the first day of January, 1878, the number of telephones manufactured and delivered to the agents of the company amounted to 5,491. These instruments were used on private lines, generally to connect two offices or other places belonging to one person, as suggested by the company. The illustration, showing a person using one hand telephone as a transmitter and the other as a receiver, gives a correct idea of the manner of using the instruments at that time. Probably not one out of ten persons who now



F. G. DABOLL.

make daily use of the telephone knows that his receiver is also a good transmitter.

The subject of using the telephone for "long-distance" transmission received consideration at a very early date, and many experiments were tried on telegraph lines, principally for one of two reasons—the telephone men were anxious to demonstrate the capabilities of the instrument, and telegraph men generally were anxious to prove that it was a humbug. Notwithstanding the general skepticism on the part of telegraph men many of the agents first licensed by Mr. Hubbard belonged to the fraternity. Sargent, Balch, Davis, Gilliland, McKinstry, Baker, Estabrook, Doolittle, and many others had been practical telegraphers all their lives and thoroughly understood the business of building and operating lines. Before the beginning of 1878, conversation had been successfully carried on with the simple magneto instruments between Boston and Salem, Boston and Providence, New York and Philadelphia, Washington and Philadelphia, and many other places.

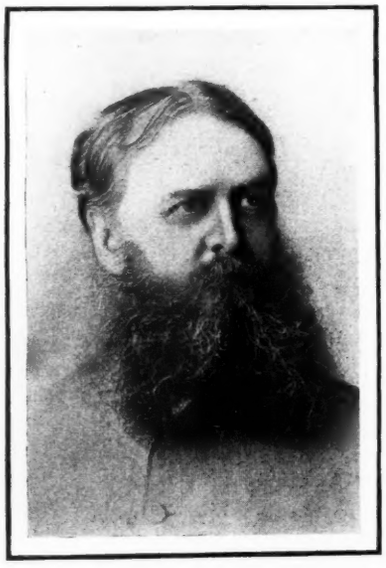
The central office plan, which provided facilities for connecting one subscriber with a large number of other subscribers outside of his own particular business, was very slow in reaching the appreciation of the public. A few months after the first announcement, Superintendent Watson issued a circular explaining the method of construction and operation of a central office system. The main features of the plan were grounded wires accommodating from five to twenty-five subscribers each, tap electric bells for signaling, lists of subscribers printed "in a small book form like a dancing programme," varying rates to subscribers in different cities from $2.50 per month to $50 per annum. After giving full directions, the circular closes with the statement that "the capital required to start this system with 150 or 200 subscribers, with twenty miles of wire, need not exceed $2,000."

After much experiment and study of the needs of the exchange business, a standard central office equipment was devised and put in use in 1879. The machinery consisted of long rows of loud ringing bells (one for each wire) with a plug switch for making the necessary connections, and a number of operators' tables entirely separated from the switch.

BURNET L. NEVINS.

One or more switchmen were employed to watch the bells, switch the wires to an operator sitting at a table and shout out the full names of the individuals, firms or officials to be connected. The cost of this equipment, with capacity for operating 500 wires (2,500 subscribers), was $2,310.

The latest exchange equipment embodies the most ingenious, elaborate and perfect combination of silent indicators, switching apparatus, etc., with storage batteries, dynamos, motors and gas engines to operate the signaling apparatus. The equipment



JOHN ELBRIDGE HUDSON.

of such an exchange to transact the business of 500 subscribers (500 wires, with one subscriber to each) would be not less than $10,000. The early exchange was a bedlam in which business was slow and tedious; the new one is the perfection of quietness and order and the business proceeds rapidly and satisfactorily.

When the telephone companies adopted the plan of giving each subscriber a number, it was generally regarded by the subscribers as a matter of great disrespect and nearly caused a rebellion. Many public functionaries, and law firms of many partners, demanded that they should be called by their full, unabbreviated titles and not be numbered like penitentiary convicts.

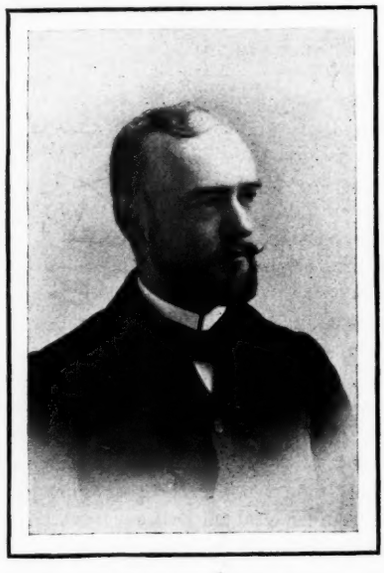
There has been a good deal of discussion and rivalry over the question where and by whom the first exchange system was established. The credit for this is generally conceded to Geo. W. Coy, who opened an exchange in New Haven, Ct., January 28, 1878, with a list of 50 subscribers. Morris F. Tyler, the present president of the Southern New England Telephone Company, was one of the original subscribers, and on the twentieth anniversary he gave a dinner in commemoration of the event, when the directory of his company contained the names of 9,000 subscribers. Among other early exchanges were those established at Bridgeport, Boston, Albany, Philadelphia and Baltimore. The regular central office system was not inaugurated in Washington until December, 1878; but in the Autumn of 1877 an embryo telephone exchange was put in operation. The agent at that place had eight or ten wires running from his office to various points, used principally for the purpose of familiarizing prospective patrons with the capabilities of the system. One of these wires led to the Capitol building and another to the office of the *Evening Star*. On that year Congress assembled in special session October 15, and very soon after, the telephone agent, after considerable persuasion, induced an enterprising *Star* reporter, stationed at the Capitol during sessions of Congress, to try the plan of sending the latest news to his paper just before the hour of going to press. On the first trial he gained a decided advantage over the other evening journals by getting some very important news into his paper.

THEODORE N. VAIL.

Thereafter, during the session, this custom was a daily occurrence. Burnet L. Nevins was stationed at the telephone office to answer the newspapermen's calls and connect the wires through. He has continued at the business ever since and is now superintendent of the operating department of the Chesapeake & Potomac Telephone Company. Just about the beginning of the year 1877, Professor Bell wrote a letter from Europe to a member of his family containing an enthusiastic prophecy of telephonic possibilities, in which he clearly and distinctly outlined, not only a single central office system, but several such systems located in different sections of a large city, connected by trunk wires, exactly as they are operated to-day. To him belongs the distinction of being the original exchange man. After a short period of reluctance and doubt on the part of exchange subscribers, they began to avail themselves of the benefits of the service to such an extraordinary extent that the managers were obliged to exercise the greatest effort and ingenuity to provide better apparatus and methods of operation, and they are still engaged in the struggle to keep ahead of the requirements.

After the exchange systems in the principal cities were well established, a plan of organizing companies to operate "extra territorial" lines for the purpose of connecting different cities was adopted. These companies have now been absorbed into the "Long-Distance" system of the American Telephone and Telegraph Company, of which Edward J. Hall is the general manager.

The National Bell Telephone Company succeeded the original organization, with William H. Forbes as president and Theodore N. Vail as general manager. Mr. Hubbard was a member of the executive committee and Mr. Alexander Cochrane was a director. The company moved its main office from Boston to Nos. 66 and 68 Reade street, New York, but after a few months returned to Boston. The National company was reorganized under the name of the American Bell Telephone Company in April, 1880. Upon the death of Mr. Forbes, Mr. John E. Hudson succeeded to the presidency, and when the office was made vacant by the death of the latter in 1900, Mr. Cochrane was chosen to fill the office. Mr. C. Jay French has been the general manager for many years.



EDWARD J. HALL.

In 1880 the standard lines were built of No. 12 galvanized iron wire, costing about $14 per mile, supported on small glass insulators and light poles or carried over the tops of buildings. Now the city lines are made in cables of from 50 to 400 insulated wires each, laid in expensive and permanent conduits. The overhead lines

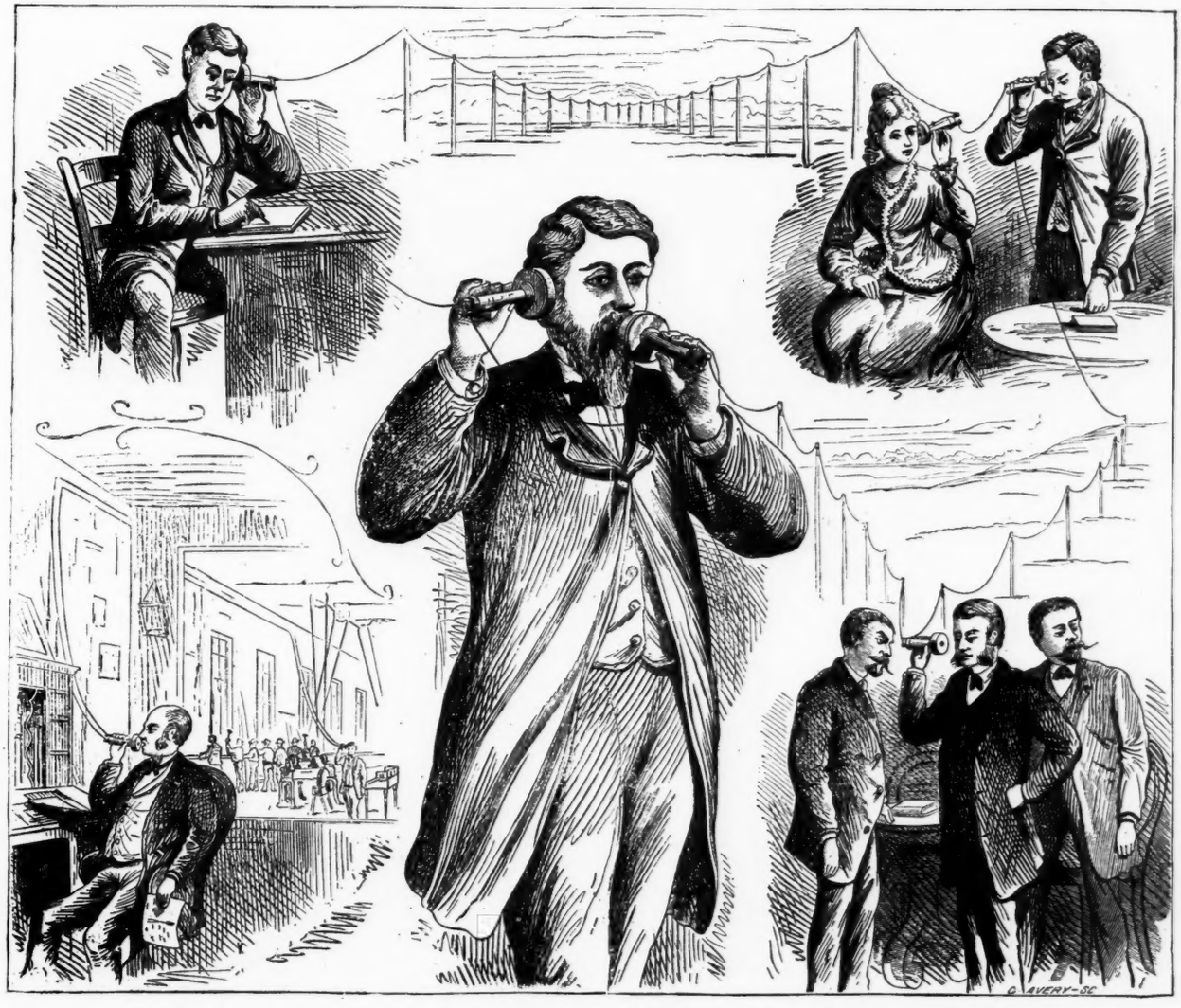
in cities use copper wire, costing over $30 per mile, while the country lines are built of very heavy and high poles and copper wire, costing over $75 per mile. The entire construction is done in a manner far superior to anything heretofore attempted in this country and not excelled anywhere in the world. On main trunk lines as many as 50 wires are in use, while the poles are erected with capacity for double that number. A 20-wire line of this description costs $1,600 per mile. In making this comparison the fact that the present *metallic circuits* require two wires while originally only one was used, must not be overlooked.

The following table gives some idea of the remarkably rapid growth of the business:

	Jan. 1, 1885.	Jan. 1, 1890.	Jan. 1, 1895.	Jan. 1, 1901.
Miles of wire..	155,791	331,642	675,415	1,520,000
Miles of underground wire.	3,417	55,823	185,845	500,000
Telephone exchanges.....	1,175	1,241	1,613	2,500
Telephone subscribers.....	137,750	202,931	281,695	650,000
Connections..	351,267,760	400,000,000	670,000,000	2,000,000,000
Persons employed.....	5,168	6,758	11,094	26,000

The number of Bell telephones in use at the beginning of each year from 1878 to 1901 are as follows:

Jan. 1, 1878..	5,491	Jan. 1, 1890..	445,000
" 1879..	18,000	" 1891..	484,000
" 1880..	53,000	" 1892..	511,000
" 1881..	124,000	" 1893..	553,000
" 1882..	181,000	" 1894..	567,000
" 1883..	238,000	" 1895..	583,000
" 1884..	299,000	" 1896..	675,000
" 1885..	326,000	" 1897..	773,000
" 1886..	330,000	" 1898..	920,000
" 1887..	354,000	" 1899..	1,125,000
" 1888..	380,000	" 1900..	1,580,000
" 1889..	412,000	" 1901..	2,000,000



THE TELEPHONE AS GENERALLY USED IN 1878 OR 1879.—REPRODUCED FROM A CIRCULAR OF INSTRUCTIONS TO TELEPHONE USERS OF THAT PERIOD.

The telephone system is the most unique thing in the world and has become so completely a part of daily human life that its extent and utility can not be measured by statistics. Every year of its existence has given a new revelation of its wonderful adaptability and brought it into more general use. It has proved to be the competitor of no other business but a valuable aid and stimulus to every industry.

All other public service systems provide special facilities which, by the aid of large numbers of experienced employés, carry on the business for the benefit of their patrons, while this places the facilities in the hands of its patrons and leaves them to use them in their own way. This fact explains the reason for the exceedingly small number of employés required for the transaction of such an immense business.

The number of exchange communications, running into the millions every year, is trifling when compared with the service done in the offices of newspapers, factories, railroads and other business establishments that have their own private telephone systems, without which it would be impossible to conduct their business.

In meeting the urgent and constantly increasing demands of public necessity, the telephone has led every other enterprise. This success has been due largely to the fact that it is practically under one central, powerful control, and that its advantages are placed at the service, not only of large corporations and persons of wealth, but are always and everywhere

ready for the use of the humblest and poorest individual.

The consolidation of local organizations and the extension of wires further and further from all the central points, which are united by the "long-distance" lines, are rapidly converting the whole Western Continent into one grand telephone exchange. The subject of telephonic transmission over long submarine cables is receiving the serious attention of able investigators, and dreamers, whose dreams sometimes come true, are talking of the possibilities of speaking communication between all parts of the earth in a universal language.

The history of the telephone furnishes complete justification of the United States patent system. By the wise provision of the constitution "to promote the progress of the sciences and useful arts" Bell for 17 years held the control and secured the profits of his invention; thereafter, for all time to come, it is given to the free use of the people.

"A GREAT MONOPOLY"

is the title frequently given the Bell telephone organization, but it is a misnomer. The business was founded on a basis of 25 per cent monopoly, 75 per cent sagacious, forceful enterprise. By the just operation of the patent laws the first element is being gradually eliminated and will soon disappear; the second has steadily enlarged the company's field of usefulness and strengthened its position. For clear comprehension of the proper relations of corporation and patron, for enterprising anticipation of the needs of the public, for liberal expenditure of money in preparing for such needs, for wise and fair administration, it is not excelled by any organization in the land. After an eventful existence of nearly 25 years it has today a splendid permanent equipment sufficient for all present needs with provision for extension to meet the requirements of the next 25 years, which in all probability will be absorbed in half that time.

THE "INDEPENDENT" TELEPHONE INTERESTS.

The history of this branch of the business is another story, and a long one. The time to write it has not come. In the last 20 years hundreds of companies have been organized and "financed." The most of them have disappeared leaving scarcely a trace behind, except in the recollections of those persons who invested money in them. The really strong, well-managed companies are prosecuting their business with vigor and the service furnished by them plays an important part in the business affairs of the country.

THE FUTURE.

The twentieth century waits in hopeful anticipation of good things the advancing era is bringing it. Across its early morning sky streams a bright gleam from the headlight of the train of progress, swiftly ascending the last grade on the divide between the Old and the New, laden with blessings manifold, the gathered treasures of a hundred years. These embrace many great instrumentalities to carry forward the mission of promoting civilization, enlightenment, universal liberty, "Peace on Earth." Of all these the simplest, the greatest, the best, is the speaking telephone.

Mr. Edison's Reminiscences of the First Central Station.

MR. THOMAS A. EDISON is not an easy man to find at home. During the day, and often far into the night, he is at the big brick laboratory building in Orange, N. J., and this building is surrounded by a very high and discouraging picket fence, in a remote corner of which is a gate and nearby a push-button. Once through this —and it is hard to get through it—various dragons lie in wait for the bold person who undertakes to interrupt one of the busiest men in the world.

Once inside the visitor is conducted into a spacious and lofty library where he waits. Here, after a time, comes to him the genius of the place, and so it was when Mr. Edison talked with one of us the other day about the starting of the Pearl street station in New York city and the birth of electric lighting as an industry.

The passing of time has left few marks upon the veteran inventor; perhaps his hair is a little grayer, but he entered the library with a springing step that would have done credit to a boy, and hailed his visitor with a flash of the old-time enthusiasm.

"So you want to talk about the old days at Pearl street," said he. "Well, I hardly know where to begin. It was something like this; the central station idea struck me all of a sudden in 1878. In those days, you know, we had arc lamps. I had been down to see Professor Barker, at Philadelphia, and he had shown me one. A little later I had seen another one—I think it was one of Brush's make—and the whole outfit, engine, dynamo and one or two lamps, was traveling around the country with a circus. At that time Wallace and Moses G. Farmer had succeeded in getting 10 or 15 lamps to burn together in series. It happened that I was comparatively at leisure then, because I had just finished working on the carbon button telephone, and this electric light idea took possession of me. It was easy to see what the thing needed; it wanted to be subdivided. The light was too bright and too big. What we wished for was little lights and a distribution of them to people's houses in just the same way that gas is sent around and burned at your fixture when you want it. I remember, along about then, Grosvenor P. Lowry thought perhaps I could succeed in solving the problem and he raised a little money and formed the Edison Electric Light Company. We started the laboratory at Menlo Park. The way we worked it was that I got a certain sum of money a week and employed a certain number of men, and we went ahead to see what we could do."

Replying to an inquiry as to how he went at the problem, Mr. Edison laughed and said, "Why it was easy. It was easy enough to see that the subdivision never could be accomplished unless each light was made independent of every other. Now it was plain enough that they could not burn in series; hence they must burn in multiple arc. It was with this conviction that I started. I was fired with the idea of the incandescent lamp as opposed to the arc lamp, so I went to work and got some very fine platinum wire drawn. As well as I remember it was made by Johnston, Mathy & Company, in London. We tried to make the platinum work but it didn't stand. Then we tried mixing in about 10 per cent of iridium with the platinum, but we couldn't force that high enough without melting it. After that came a lot of experimenting, covering the wire with oxide of cerium and a lot of other things such as the Welsbach people use nowadays. Then I got a great idea; I took a cylinder of zirconia and wound about 100 feet of the fine platinum wire on it coated with magnesia from the syrupy acetate. What I was after was getting a high resistance lamp and I made one in that way that worked up to 40 ohms; but the durned oxide developed the phenomena that Dr. Nernst has run up against lately—I didn't see it then as he does now—and the lamp short-circuited itself!

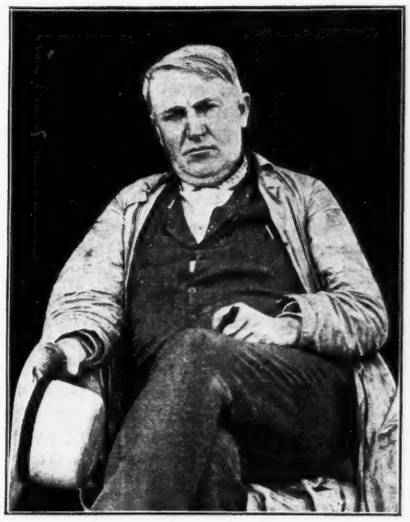
"After that," continued the inventor, warming to his subject, "we went fishing around and trying all sorts and shapes of things to make a filament that would stand. We tried silicon and boron and a lot of things that I have forgotten now.

The funny part of it was that I never thought in those days that carbon would answer because a fine hair of carbon was so sensitive to oxidation. Finally I thought I would try it because we had got very high vacua and good conditions for it. There were quite a lot of us in those days that used to talk things over together at Menlo Park. There was Charlie Hughes, and Bachelor, and Upton and poor Kruesi. C. S. Bradley came with us a little later, on our central station work.

"Well, we sent out and bought some cotton thread and carbonized it and made the first filament. We had already managed to get pretty high vacua and we thought maybe the filament would be stable. We built the lamp and lighted it; it lit up, and in the first few breathless minutes we measured its resistance quickly and found it was 275 ohms—all we wanted. Then we sat down and looked at that lamp; we wanted to see how long it would burn. There was the problem solved—if the filament would last. The day was—let me see—October 21, 1879. We sat and looked and the lamp continued to burn and the longer it burned the more fascinated we were. None of us could go to bed and there was no sleep for over 40 hours; we sat and just watched it with anxiety growing into elation. It lasted about 45 hours and then I said 'If it will burn 40 hours now I know I can make it burn a hundred.'

"There we were. We saw that carbon was what we wanted; the next question was what kind of carbon. I began to try various things and finally I carbonized a little strip of bamboo from a Japanese fan and found that that was what we were seeking."

It was evident that Mr. Edison was pleased as he recalled these early days of the incandescent lamp and the joy of creation that he must have felt in reaching his desideratum at last; but the lamp was by no means all. He continued, "I had the central station in mind all the time. I wanted to use 110 volts. Now there is no use for you to ask me why, because I don't know, but somehow that figure stuck in my mind and I had calculated that, if we could get the voltage that high, the copper cost would be somewhere within sight. I got an insurance map of New York city. Did you ever see one? Many big fat volumes, full of plates, with every elevator shaft and boiler and house top and fire wall in town set down and duly colored in its place. I laid out a district and figured out an idea of the central station to feed that part of the town from just south of Wall street up to Canal and over from Broadway to the East River; but what I wanted to know was whether my lamps could be made in quantity and depended upon. We went to work and made up a lot of them. W. J. Hammer had charge of the tests and they seemed to work out all right. Then it was that we invited the Board of Aldermen out to Menlo Park." Here Mr. Edison chuckled. "It was a great day," he said, "or a great night, rather. I have forgotten the exact date, but it was either the second or third of January, 1880. The aldermen came out in a special train from New York and the first thing they saw were the streets of Menlo Park all lit up with incandescent lamps. You know," he explained apologetically, "that there was a land speculation out there then. We had the lamps strung along on two big wires and we could light or extinguish one without affecting the others, and this was a thing that seemed magic to the aldermen. I remember that Mr. Hiram Maxim was at this exhibition."



MR. EDISON IN HIS WORKING CLOTHES.

From the way he smiled at the remembrance, Mr. Edison must have enjoyed the aldermanic visit. He went on: "The station idea was still mighty strong with me. Why, I knew where every hatchway and bulkhead door in that district of New York was and what every man paid for gas. How did I know? Simplest thing in the world. I hired a man to start in every day about two o'clock and walk around through the district noting the number of gas lights burning in the various premises; then at three o'clock he went around again and made more notes, and at four o'clock and every other hour up to two or three o'clock in the morning. In that way it was easy enough to figure out the gas consumption of every tenant, and of the whole district; other men took other sections. Simple, wasn't it?

"I found there was 750 freight hoists; like Sellers, I figured every one would have a motor.

"We were now fairly committed to the lighting project and started in to build a central station. You can't imagine how hard it was. There was nothing that we could buy or that anybody else could make for us. We built the thing with our hands, as it were. We went to work at Menlo Park and started a lamp factory. Poor Kruesi* was set to work making the tubes over in Washington street, and we hired a kind of a second-class machine-shop in Goerck street and there started out to make the dynamos. We went at it with our own money and credit." Here Mr. Edison's eyes twinkled and he said, "I believe it was mostly credit. Anyhow, we struggled along and we got the money put up for the Pearl street station by starting the New York Edison Illuminating Company. I planned out the station and found where it ought to go, but we couldn't get real estate where it was wanted. Why, man, they charged us $75,000 apiece for two old bum buildings down in Pearl street, where we finally settled. I tell you it made my hair stand on end. We had very little room and we wanted a big output. There was nothing else for it but to get high-speed engines, and, as you know, there were no high-speed engines in those days. I had conceived the idea of a direct-coupled machine and wanted to hitch the dynamo direct to the engine without belting. I couldn't see why, if a locomotive could run at that speed, a 150-horse-power engine could not be made to run 350 turns a minute. The engine builders, when I asked them about it, held up their hands and said 'Impossible!' I didn't think so. Finally I found C. H. Porter and I said to him: 'Mr. Porter, I want a 150-horse-power engine to run 700 revolutions per minute.' He hemmed and hawed a little while and finally agreed to try to build it—if I would pay for it. I believe he charged me $4,200 for it. He got it finished finally and sent it out to the Park and a fellow of the name of Ennis along with it. He was one of the nerviest chaps I ever saw. We set the machine up in the old shop and we had some idea of what might happen, so we tied a chain around the throttle valve and ran it out through a window into the woodshed, where we stood to work it. Now, if you remember the old shop you know it stood on top of one of those New Jersey shale hills. We opened her up and when she got to about 300 revolutions the whole hill shook under her. We shut her off and rebalanced and tried again, and after a good deal of trouble we finally did run up to 700, but you ought to have seen her run. Why, every time the connecting rod went up she tried to lift that whole hill with her! After we got through with this business we tamed her down to 350 revolutions (which was all I wanted) and then everybody said, 'Why, how beautifully it runs, and how practicable such an engine is!' Now, don't you know, I knew they would say that? Didn't you ever find out that trying to do the impossible

*Mr. Kruesi died recently.—[EDS.]

makes about half the impossible seem easy?

"We closed a deal for six engines and I went to work in Goerck street to build the dynamos onto them. Of course, we built them by guesswork. I guessed at 110 volts—and didn't guess enough. That's why, if you want to know, the extra pole pieces were put on those old machines. They managed to lift the voltage to what I wanted."

Going back to the Pearl street station idea, Mr. Edison said: "While all this was going on in the shop we had dug ditches and laid mains all around the district. I used to sleep nights on piles of pipes in the station, and do you know I saw every box poured and every connection made on that whole job? There wasn't anybody else who could superintend it.

"Finally we got our feeders all down and started to put on an engine and turn over one of the machines to see how things were. My heart was in my mouth at first, but everything worked all right and we had more than 500 ohms insulation resistance. Then we started another engine and threw them in parallel. Of all the circuses since Adam was born we had the worst then! One engine would stop and the other would run up to about a thousand revolutions and then they would see-saw." Mr. Edison's eyes twinkled with animation at the thought.

"What was the matter? Why, it was those durned Porter governors! When the circus commenced the gang that was standing around ran out precipitately and some of them kept running for a block or two. I grabbed the throttle of one engine and E. H. Johnson, who was the only one present to keep his wits, caught hold of the other and we shut them off. Of course I discovered then that what had happened was that one set was running the other one as a motor. I then put up a long shaft connecting all the governors together and thought this would certainly cure the trouble, but it didn't. The torsion of the shaft was so great that one governor still managed to get ahead of the others. Well, it was a serious state of things, and I worried over it a lot. Finally I went down to Goerck street and got a piece of shafting and a tube in which it fitted. I twisted the shafting one way and the tube the other as far as I could, and pinned them together. In this way, by straining the whole outfit up to its elastic limit in opposite directions, the torsion was practically eliminated and after that the governors ran together all right.

"About that time I got hold of Gardiner C. Sims and he undertook to build an engine to run at 350 revolutions and give 175 horse-power. He went back to Providence and set to work and brought the engine back with him to the shop. It worked, but only a few minutes, when it busted. That man sat around that shop and slept in it for three weeks until he got his engine right and made it work the way we wanted it to. When he reached this period I gave orders for the engine works to run night and day until we got enough engines, and when all was ready we started the engine. The date was September 4, 1882—a Saturday night. That was when we first turned the current on to the mains for regular light distribution and it stayed on for eight years with only one insignificant stoppage. One of those first engines that Sims built ran twenty-four hours a day, 365 days in the year, for over a year before it was ever stopped."

Questioned about the details of the work in those now ancient days, Mr. Edison said: "Of course we had the whole thing to design in gross and in detail and everything to standardize; there were meters, safety catches, fuses and all the rest of it, but somehow we managed to work it out. At first we had horrible mismanagement. The only title to existence that such a concern had was its ability to make money, and we didn't seem to make any at first. Finally I went to Chinnock—of course you know who C. E. Chinnock is—and told him that if he would take hold of the thing and make it work I, personally, would give a good big bonus beside his salary. Well, sir, that man pitched in and inside of eight or nine months had earned and received his bonus.

"I don't remember who it was who wanted to connect in a lot of places that used the light only occasionally, but some such establishments were on our mains and one of them was the Stock Exchange. Now the Stock Exchange isn't lighted very often and there were a good many lamps there. I remember that one day, along in the holidays, I think it was, we were loaded pretty well up to our limit and I was terribly afraid that that Stock Exchange would have its lights turned on and overload us irretrievably. I was in that part of the town and all at once noticed that the Exchange people had turned on their lights. I got to a telephone and called up Chinnock and asked him how things were.

"'How is it with you at the station?' said I.

"'O, bully,' says he.

"'Are the machines standing up to it?' I asked him.

"'Sure,' says he, 'but everything's red hot and the ammeter has made two revolutions!'"

Mr. Edison went on to recount some of the details of the work. Those were the days of the old chemical meter which, as every one remembers, contained two jars of a liquid solution which might, of course, if the weather became cold enough, freeze. "Those meters," said the inventor, "gave us a good deal of apprehension. I was afraid they would freeze, especially in the water-front neighborhood where the commission houses are. You know those people there keep the front door open all the year round and it gets pretty cold inside their places in the Winter time. So I went to work and put an incandescent lamp in each meter case, with a thermostat strip that would make a contact through the lamp when the temperature fell to 40 degrees. Well, you ought to have seen the trouble that that simple thing got us into. There came along a cold snap of weather and the first thing I knew the telephone began to ring about every five minutes and people would say:

"'Our meter's red hot; is that all right?'

"Then another one would call up and say:

"'Our meter's on fire inside and we poured water on it. Did that hurt it?'"

Asked about measuring instruments and methods of keeping the station up to an accurate and uniform voltage, Mr. Edison said, "Voltmeters? We didn't have any. We used lamps. Once, down there, we found our insulation resistance had gotten down to 100 ohms; the directors seemed to be scared, but I told them that if it didn't get below one ohm we were all right. I used to have a good deal of trouble with mathematicians at that time, but I found after a while that I could guess a good deal closer than they could figure, so I went on guessing. Why, in our early work there we used to hang up a shingle nail, tie it on a string alongside one of the feeders, and use that for a heavy-current ammeter. It worked all right. When the nail came close to the feeder we screwed up the rheostat a little and kept the lamps in the station looking about right.

"That was the time that I conceived the notion of pressure wires running back from the distribution centres of the various feeders. You know, in those days," Edison said with an apologetic smile, "our lamps weren't *rugged* at all. What they wanted was just 110 volts, and not another volt.

"Yes, we were a good deal troubled with getting fixtures and sockets and small trimmings of that kind built right. Bergmann had a little place on the east side where he made gas fixtures, and he went into making sockets and fixtures for us and did well with them."

Here the conversation turned to days even older than those of the Pearl street station, and we talked a while about dynamo building in the Dark Ages. "When I started making dynamos." Mr. Edison said, with an introspective look, "I was told that to get the best effects the resistance of the machine must be equal to that of its load! Did you ever hear of such foolishness? I thought it was darned strange to lose half of the energy I generated in the machine, because what I was after was to *get the stuff out and sell it!* I had an old Gramme machine and I worked over it. It had a terribly high resistance. I figured out that if one turn on that armature would give one volt, the way she stood, by making great big magnets I could get more volts. I went ahead on that line and I remember I made one little machine that had a small armature about as big as your fist and about two tons of cast-iron in its field magnets. It might not look like much to-day, but it worked all right when the outside resistance was 30 times as big as that in the machine. That was what started me on the large field magnets. I remember at a dinner on the other side talking to Werner Siemens and Hefner von Alteneck

and telling them that what we needed was a great big magnet to bring the juice out of the armature. They agreed with me, but," and here he chuckled, "do you know, both of them said they had thought of it before? When I got back I went to work and made my magnets big and made them long—made them too long, as Dr. Hopkinson found out for me. He was a great man and understood his job. He figured out that making the magnets short and cutting down the air-space was the thing, and he was right. After all, in those days all of us were guessing—and I happened to be a pretty good guesser."

We were led to speak at this point of the recent death of Mr. William H. Moore, who was once associated with Mr. Edison. This started Mr. Edison on some reminiscences of the hunt for materials for the filaments at the time when bamboo seemed the most promising. "Why," said he, "I sent a school teacher from Orange—I have forgotten his name—to Sumatra, and another fellow up the Amazon. He got stuck somewhere up there but worked his way over through Bolivia and got back. Finally, Moore went to Japan and got the real thing there. We made a contract with an old Jap to supply us with the proper fibre, and that man went to work and cultivated and cross-fertilized bamboo until he got exactly what we wanted. I believe he made a fortune out of it. I tell you, in those days the boys hustled hard. One man went down to Havana and the day he got there he was seized with the yellow fever and died in the afternoon. When I read the cable message that told of it in the shop about a dozen of the boys jumped up and asked for his job! Those boys were a bright lot of chaps and sometimes it was hard to select the right ones for a particular piece of work. I once got an order from England to send over 15 men expert in telephone work, so I went to work and rigged up some telephones and did all sorts of things to 'em. I would stick the point of a jack-knife through the insulation in spots and cut a wire, and in various ways introduce 'bugs' into those instruments; then the boys were set to work to find out what was the matter with them. If a fellow could find out 10 times inside of 10 minutes what the various troubles were he got his passage paid and was started. About one out of three of the boys managed to stand this test and I believe that everyone of them who went abroad made money. This was back in 1878 or 1879."

Asked about his early inventions before he began to work on the electric light problem, Mr. Edison said, "When I struck the telephone business the Bell people had no transmitter, but were talking into the magneto receiver. You never heard such noise and buzzing as there was in those old machines. I went to work and monkeyed around and finally struck the notion of the lamp-black button. The Western Union Telegraph Company thought this was a first-rate scheme and bought the thing out, but afterward they consolidated and I went out of the telephone business."

Asked about the invention of the fuse wire, Mr. Edison laughed as he recalled the first occasion for its use. "Why," he said, "the night those aldermen came out to Menlo Park I had figured that an interruption would be serious and had thought out the scheme of putting some fine copper wire in as fuses in various places. There was a fellow in the party—I won't mention his name—and he had a little piece of heavy wire in his hand. While the aldermen were looking at some lamps strung between two bare mains this fellow walked up and short-circuited the mains with his wire. I believe he was the most surprised man of the party, because only three lamps went out. The reason that led me to think of the fuse wire was that we weren't flush of dynamos in those days. I had burnt out two or three and I saw that something was needed to prevent that happening again. After my experience with my short-circuiting friend, I had fuses put in all over."

The talk turned to the early days of the electric railway, and Mr. Edison said: "Yes, I was in that, too. I had a three-mile road out there in 1883, and we used to pull freight cars up to the laboratory on it. We made as much as forty miles an hour at times. Now that railroad project seemed to me to be a mighty good thing. You know I had a board of directors in those days—men with bulging foreheads—fellows that thought away ahead into the future, and I went to work and carefully elaborated all the ideas I had for electric railways and submitted them to the board. They considered the subject carefully and fully, and unanimously decided that there was no money in the electric railroad and that they would let it alone!

"What was my first electrical invention? You would never guess. It was a machine to record votes in Congress. It was a mighty good invention. I had a lot of iron type, each member's name being set up in a line, and these lines were controlled by push-buttons and electromagnets so that each man could bring his name up on the 'aye' side or the 'no' side, as he pleased. I used chemically sensitized paper to record them and the thing worked fine. A brother telegraph operator named Sam—I have forgotten the rest of his name—and myself were dead sure that we were going to make $50,000 out of it. He took the thing before a Congressional committee and the first thing they told him was that if there was anything on earth that the members of Congress did not want it was just that kind of thing, because the only right the minority had was to delay the game! After that experience, which was in 1869, I knew enough not to invent anything again until I was sure it was wanted."

Going back to his own early history and the story of his connection with the electrical field, Mr. Edison said that one of the first things he went into was a messenger call-box or domestic telegraph system. "We got the thing into shape," he said, "and made 200 instruments and then sent two men out to get subscribers, but they tramped around without avail day after day and our hopes sank and sank further and further. Finally a man named Brown came along and the first day he tackled the job he got six. This sent our hopes up again and after he got the lines loaded up with subscribers we sold the scheme out and realized a good profit on it. After that I worked out the stock ticker.

"What were my principal patents? Good gracious, man! Oh, you don't mean patents — inventions? Why, first and foremost, the idea of the electric lighting central station; then—let me see, what have I invented? Well, there was the mimeograph, and the electric pen, and the carbon telephone, and the incandescent lamp and its accessories, and the quadruplex telegraph, and the automatic telegraph, and the phonograph and the kinetoscope, and—I don't know—a whole lot of other things."

There was only one time during the interview that Mr. Edison showed any signs of annoyance or impatience. This was when he talked about some of the daily newspapers and their treatment of him. He said: "I've absolutely been obliged to set this watchdog system in operation, but the worst of it is that these fellows who come out here go back without ever having seen me or heard me speak a word and write out alleged interviews that make me seem foolish to people who don't know me. I think it's outrageous that I should be subjected to this kind of treatment. Interviews, so-called, with me have appeared lately when I've never seen or spoken to one man connected with the sheet that prints them. I haven't seen a reporter for a newspaper to talk with him for four years, and I want you to say that every alleged interview that appears in the daily press of New York city as from me is a fake, and that I have no responsibility for any of them. There are two papers over there in particular that have annoyed me exceedingly and one in Philadelphia — a weekly — keeps its man coming here and coming here, but"—and here Mr. Edison smiled meaningly—"the man will never get over that fence!"

Asked if it were possible, in his view, to achieve the direct production of electricity from heat or from combustion without the intervention of mechanical agencies, he said: "Yes, almost anything is possible, and I really believe that some day we may get such a process that will show an efficiency of thirty or forty per cent. Some experiments we have made over here have shown an efficiency of four per cent, and, as little as this is, it is certainly promising."

Asked if he thought the achievement of the twentieth century would surpass that of the nineteenth in invention, and especially in the application of electricity, Mr. Edison, with a glow of enthusiasm, said: "It certainly will. In the first place there are more of us to work and in the second place we know more to start on, but, all the same, none of us knows anything about anything. We are only starting. The achievement of the past is merely a point of departure and you know that, in our art, 'impossible' is an impossible word."

The History and Effect of Electrical Patents.

By George H. Benjamin.

YOUR REQUEST THAT I should express an opinion regarding the effects of patents upon the electrical industry for the past twenty years presents a question of considerable difficulty.

It must be borne in mind at the outset that many inventions now in use would never have seen the light of day had it not been for the prospect of reward which patents hold out to inventors. Further, that many electrical companies would never have been organized had it not been for the hope that the patents owned by such companies would prove, in some sense, controlling in the industry.

Experience has demonstrated that in a large measure the hopes of inventors and corporation managers have not been realized. Very few inventors have derived any considerable profit from their inventions, and the great majority of the corporations organized within the last 20 years have ceased to exist. The electrical industry of to-day is, as is well known, controlled—both in this country and Europe—by a few large corporations, and it is believed by those best informed that such control is attributable much more largely to possession of large sums of money and good business methods rather than to the protecting influence of patents.

A careful examination of the litigation of the past 20 years clearly demonstrates that it is practically impossible to maintain an exclusive monopoly based upon a patent, when the industry to which the patent relates is one which normally reaches a considerable size, owing to the demands of the public. Or, put in other words, the power of the United States courts to control infringement is limited by the extent of the use of the infringing thing. Patents are a good deal like wills, excellent, unless their validity is seriously questioned.

About the first attempt to create a monopoly in the electrical industry based upon a patent, was that made by the "Gramme Company." The patents of Gramme were thought to be controlling for the dynamo then considered useful; but within two years these patents were held void by reason of the expiration of prior foreign patents. Soon followed a suit based upon the ring clutch of the Brush lamp; this patent was held void. Later, suits based upon the Goulard & Gibbs patent for electric transformers; Edison's carbon filament for electric incandescent lamps; Edison's feeder main, compound winding and many other patents relating to electric railways owned or controlled by some one of the large electrical companies. Without having tabulated the decisions for and against patents relating to the electrical industry, I think I am safe in saying that the majority of decisions have served to render the patents sued on valueless to their owners.

A well-known inventor some years ago in talking about patents stated that he looked upon a patent as a good deal like a scarecrow, an excellent thing to plant in a field of industry to scare off stupid crows; but a mighty poor thing to fight with when crows (and for crows read men of business ability) entered upon a field of industry.

I do not wish to be understood as stating it as my opinion that patents are valueless to an industry, for I believe quite to the contrary. I look upon patents as a valuable adjunct to any business; but I do not consider patents as a safe basis upon which to found a business.

An experience of some twenty-five years in dealing with corporations having a large number of patents has taught me that corporation managers place too much reliance upon the protecting value of patents. They seem to assume that the possession of a patent is all that is required. Mr. Edison's remark relative to patents is very much in point in this connection; he at one time stated as his opinion that any fool could get a patent, but that it took a very wise man to manage a patent; and here is the rub. Corporations acquire patents but they do not properly manage patents. In other words, they show little intelligence in handling patents. The extent of the management usually consists in bringing ill-advised suits, the idea commonly being to crush out the competitor by vexatious and expensive litigation.

I have personally watched a large number of litigations based upon patents, with a view of determining the effect upon competitors, and I have yet to learn that the crushing idea was effective. On the contrary, I observed that such suits in a majority of instances have proved boomerangs which materially aided in the wrecking of the company which began the suits. Year after year I have seen the profits of corporations spent in an attempt to sustain patents; profits which, if used in ordinary commercial channels, would have advanced the business interest of the companies much more rapidly than would have been or was the case were the patents sued unsustained. Further, as a consequence of such litigation I have noticed that many companies were attracted and influenced to enter as competitors in the field of industry from the very information offered by such suits.

As bearing upon the question of the value of patents to an industry, it is well to compare the progress of such corporations as the Standard Oil Company, the American Sugar Refining Company, American Cotton Oil Company, and other similar corporations, all of which own patents, and large numbers of patents, with that of the electrical companies. In the one case the business has always been managed upon a purely commercial basis and the patents merely considered an adjunct. Whereas, on the other hand, the patents have been the controlling factor, and the commercial side used largely in support of the assumed monopolies based upon the patents.

From the above it will be seen that I am generally of opinion, that while patents have been of a distinct value in developing the scientific side of the electric industry, they have been a detriment to, and have not aided in the development of, the commercial side of the industry. I know that my opinion, as thus expressed, is very radical and not in accord with generally conceived ideas, and will subject me to more or less captious criticism. I am, however, satisfied that the commercial history of the industry for the past 20 years fully bears out the opinion which I have thus expressed.

George H. Benjamin, M.D., Ph.D., born in New York, in 1852, and has been well known in later years as a patent lawyer and scientific expert. He has appeared in many important litigations before the Federal Courts during the last fifteen years. Mr. Benjamin was the American representative for the Messrs. Siemens, of Berlin and London, and has done much work in metallurgy and electricity. He is competent to speak with authority on all subjects connected with patents and the Patent Office.

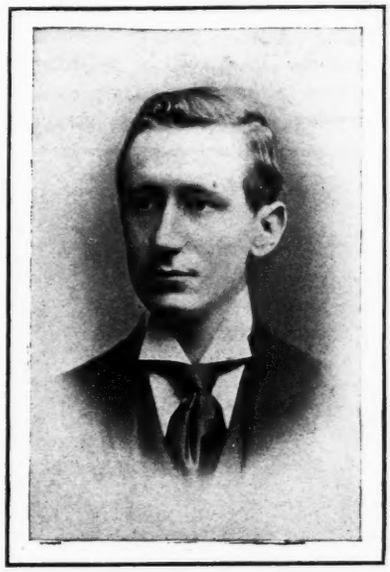
Wireless Telegraphy and the Earth.

By Professor John Trowbridge.

IT HAS BEEN a favorite thought with many imaginative minds that some day we shall be able to modify the electrical charge of the earth in such a manner as to send messages from one point to another without wires. No one has brought forward experimental evidence that this method is within the range of probability. I have lately made an experiment with a storage battery of 20,000 cells, which, I believe, bears directly upon this question. Let us see, in the first place, what rôle the earth plays in the present method of wireless telegraphy.

It has been a mooted point in regard to Marconi's system whether the earth connections of the sending and receiving apparatus are essential. For short distances they do not seem to be; messages can be sent and received without them. In order to study this question MM. Vellot J. and L. Lecarme made some observations early in the past year, an account of which is contained in the *Comptes Rendus,* May 14, 1900. The experiments were conducted on the plain of St. Denis, in France, and the sending apparatus was placed at the surface of the earth in the usual manner, while the receiving apparatus was in a balloon which rose to the height of 800 metres and was distant about six kilometres from the sending station. It was found that messages could be received in the balloon although there was no earth connection—and the authors therefore conclude that an earth connection is not essential for great distances. It will be noticed, however, that six kilometres is not a great distance and is fairly within the range of the magnetic waves which emanate from the vertical wires of the sending apparatus. The experiment of the Frenchmen, therefore, does not touch the question of the rôle which the earth plays in wireless telegraphy.

It is not improbable that the earth acts as a condenser between the sending station and the receiving station. Let us suppose that a charge runs into this condenser at the earth of the sending station



Guglielmo Marconi.

and surges back and forth in synchronism with the waves sent out by the sending spark. The receiving station, with its mast or connecting wire, could receive these surges. According to this view a charge would flow over the surface of the earth or water, surging to and fro according to the laws of electrical oscillations in condensers. We should therefore expect that hills would offer no obstacle to the transmission of signals, for the electrostatic charge would surge over the surface of the earth.

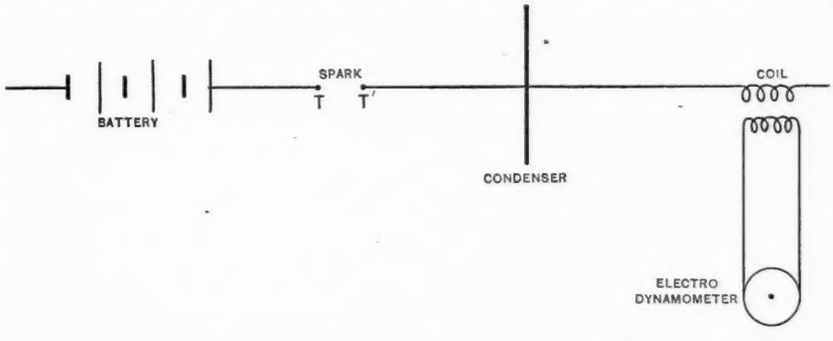


Diagram of Wireless Telegraphy Apparatus.

I proceeded to test this theory in the following manner: One pole of a battery of 20,000 storage cells was insulated, the other was brought to a distance of about one-quarter of an inch from the end of a wire which led to a large metallic surface —about 400 square feet. This surface was also connected to a wire which terminated at the end in a coil. This coil was in a position to act inductively on another coil which was connected to the terminals of a Giltay electrodynamometer. (*Ann. der Physik,* No. 25, 1885.)

The arrangement of apparatus is shown in the diagram herewith. When the spark terminals TT′ were at a suitable distance the battery sparked into the condenser and the charge thus communicated surged to and fro and produced a deflection of the electrodynamometer. Here the condenser takes the place of the surface of the earth and the coil serves in place of a coherer. It was replaced by a coherer with the usual connection to a relay battery which Marconi employs, and messages were sent in a perfect manner. The tall masts, at considerable distances, seem, therefore, to act as an additional distributed capacity, and it would be desirable to increase the capacity at the receiving station in a more compact form.

I repeated this experiment by replacing the condenser by the water-pipe system of the laboratory and connected the coherer to the gas-pipe system. The electrostatic surging in this case must have taken place over a large earth system and the transmission of signals was unmistakable. In another experiment the coherer was attached to the water-pipes in a house nearly a mile from the laboratory and signals were obtained, due to the electrostatic oscillations produced in the laboratory. No poles or masts were employed. My experiments lead me to believe that the electrostatic action propagated over the surface of the earth is mainly instrumental in producing the cohering action in the Branly tube, which is now used in wireless telegraphy; at least, when the distance between the sending and receiving stations is considerable.

It is interesting to notice that my experiments imply also an oscillation of the large battery at each charging of the condenser line. I have shown previously that such a large accumulator does oscillate when discharged.

Professor John Trowbridge, Rumford professor of the application of science to the useful arts in Harvard University, and director of the Jefferson physical laboratory of that institution, was born at Boston, Mass., in 1843. His contributions to physical science have placed him in the front rank of experimentalists. His late work on electric currents of high potential, upon X-rays and similar radiations, and upon wireless telegraphy and space signaling will be remembered by readers of technical and scientific literature. Professor Trowbridge is the author of "The New Physics" and other books and many papers and contributions to the technical press.

Some Early Arc Lighting Experiences.

By George W. Stockly.

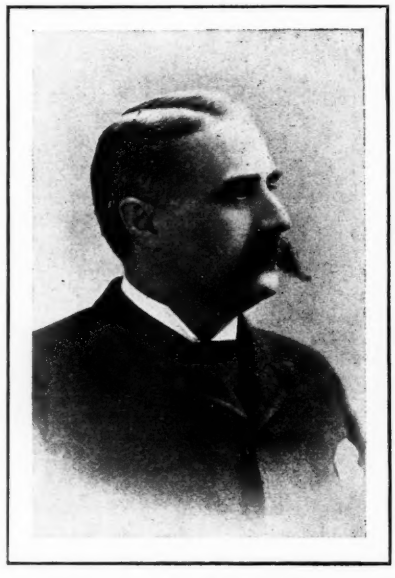
THE EARLY DAYS of the electric light were not so long ago, if one measures the passage of time in the usual way, but so much has happened in the crowded years that have intervened since the new illuminant took its place in competition for public approval that, in looking back over it, the time seems very long and the early days extremely remote. In March, 1873, I was the first teller of the Commercial National Bank, of Cleveland, Ohio. On the first day of the following month I left the bank to fill the position of vice-president and general manager of what was then known as the Telegraph Supply and Manufacturing Company, of Cleveland, of which Mr. George B. Hicks was president. He will be remembered as the inventor of a telegraph repeater that bore his name. On the very day that I started my new duties Mr. Hicks was stricken with paralysis and remained unconscious until his death a month later. I was thus thrown upon my own resources to learn the business as best I could.

Our first efforts in the business line were the manufacture of telegraph instruments, automatic fire alarm instruments and a number of other electrical devices of the same general character. In one way and another we managed to get along until March, 1877, when I made a contract with Mr. Charles F. Brush, whom I had known from his early boyhood. Mr. Brush was then 28 years old. The new contract with him added an electric light branch to our business, and this in a few years became practically the only business of the company. Not long after this time the name of the concern was changed to the Brush Electric Company.

In 1877 the Franklin Institute, of Philadelphia, undertook a series of experiments to determine which of various electrical machines then on the market it should purchase. On the committee of the Institute having the matter in charge were Professors Elihu Thomson and Edwin J. Houston, both of whom, if I remember rightly, were at that time teachers in the high schools of Philadelphia. These gentlemen and others experimented for some months with the machines and finally, upon their recommendation, the Franklin Institute decided in favor of the Brush machine and purchased one from us for its uses.

When Mr. Brush had completed the construction of his first electric lighting dynamo he came to me and asked me to find, if it was possible, an electric lamp to use in connection with it. A thorough and prolonged search through all available sources in this country and abroad did not result in the discovery of the required lamp, so Mr. Brush went to work to devise one himself which would answer his purposes. This he succeeded in accomplishing admirably and, in 1878, he produced the lamp which we afterward called the reversed helix lamp.

By slow degrees and with great effort some of these early machines and lamps were introduced into practical use. Probably the first machine that was sold was disposed of to Dr. Longworth, of Cincinnati. This was at the beginning of 1878. Mr. Brush went down to Cincinnati to show the Doctor how to work the machine and the light was exhibited from the balcony of his dwelling. It was a 4,000-candle-power light and, of course, it attracted a big crowd of the natives. Mr. Brush used to relate with great amusement that when the light was first shown there he stood out with the crowd in front of the house and heard a man learnedly explain that the box on top of the lamp was full of oil and the side rods were pipes that led it down to the flame.



CHARLES FRANCIS BRUSH.

Among others that were sold were one each to Messrs. Loeser & Company, of Brooklyn, N. Y., and Freeland Loomis & Company, of Boston, Mass.

In the year 1878 the Brush machines and lamps were exhibited at the Mechanics Institute, in Boston, and also at the American Institute Fair, in New York city. Great success attended both of these exhibits and within one year from that time a contract was made by our company for the electric lighting of Monumental Park, in the city of Cleveland, Ohio, with 12 Brush lamps. These were distributed through the park on poles about 20 feet high.

When the lights were started in this park it was crowded with people and so great was the popular interest in the light and so wild and varied were the stories that had been told concerning it that many of the persons assembled there brought dark spectacles or pieces of smoked glass to prevent their being blinded by the tremendous glare that was to be turned loose upon them.

We had much trouble in those early days with carbons. The first ones that we were able to get were crooked and soft and of very high electrical resistance, and they also cost a great deal of money. The idea of copper plating the carbons was devised at this time. In the first year of electric lighting carbons were sold at the rate of $240 a thousand, though nobody ever thought of buying as many as a thousand at a time.

The lighting of the little park in Cleveland was the first arc lighting from a central station to be done in the United States. Subsequently, but not very long afterward, the Brush Electric Light Company, of Cleveland, a local lighting corporation licensed by the parent company, was formed and took over the lighting of the park, which it continued. At about the same time the Brush Electrical Engineering Company, of London, was formed and this concern has been in continuous existence since. I believe it is now in a very prosperous condition.

From these small beginnings the company's business rapidly increased until the year 1889, when I sold practically the whole of its stock to the Thomson-Houston Electric Company, of Boston. Subsequently this concern incorporated its own and the Brush interests with the Edison company to form the General Electric Company, which still exists under that corporate title.

Mr. George W. Stockly was born in Cleveland, Ohio, in 1843. On leaving the public schools he spent five years in the law offices of Willey & Cary, and in the transportation business. After being paying teller for seven years in the Commercial National Bank, he became vice-president and general manager of the Telegraph Supply and Manufacturing Company, in 1873. By act of legislature the name of that company was changed to the Brush Electric Company, and in 1879 Mr. Stockly assumed the presidency, which he retained until 1890, when its stock was sold to the Thomson-Houston Electric Company for about $3,000,000 in cash.

A Review of the History of Electric Lighting.

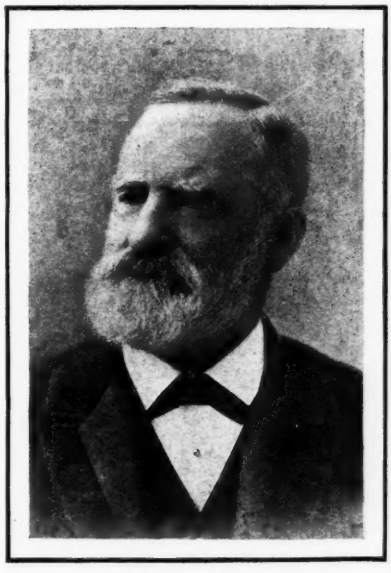
By Edwin R. Weeks.

THE PERIODS of activity and quiescence in discovery and invention which together produced the modern system of electric lighting are one of the peculiar features of its development. Almost every experimenter in electricity had a dim vision of something that might be done with von Guericke's spark of light, but the obstacles in the way proved always insurmountable. The brilliant achievements which have followed in rapid succession since continuous development began in 1875, have rendered possible varied and widespread applications of electricity, and make it difficult to realize that scarce 25 years have elapsed since the birth of electric lighting. Equally interesting are the disappearance and reappearance of discoveries which at first promised little, but like "the stone which the builders rejected," proved useful in the end. This is preeminently true of the alternating-current dynamo, the first to be produced, and the last to receive recognition.

The discovery of electric light is almost coincident with the beginning of the nineteenth century, and belongs to the generation which witnessed the introduction of illuminating gas in London. The new fields which gas offered to industry and its ease of production and distribution without complicated machinery and an unknown force, gave it prominence, and, for two generations, satisfied the demand for a convenient artificial light.

When Sir Humphrey Davy, in 1810, demonstrated that, with charcoal terminals, a voltaic battery will produce a sustained and brilliant light, he realized that he had discovered an artificial illuminant surpassing any then known. He produced the arc light in air and in vacuum, the incandescent light in air and in vacuum, and made use of rods of carbon from vegetable fibre. To the casual observer, it would seem that he had solved the problem. But Davy worked in the realm of pure science and was not primarily an inventor. The practicable electric lamp awaited mechanical appliances which belong in another field of discovery, and Davy's air-pump and primary batteries furnished too primitive and costly a method of production to excite the ingenuity of inventors at a time when gas was considered the *ne plus ultra* of artificial lighting. It remained for other generations to furnish the solution which has earned many fortunes and added to the "Hall of Fame" some of its most illustrious names.

In 1831, Faraday, a pupil of Davy, wrote, "I am so busy now on electro magnetism, and I think I have got hold of a good thing, but can't say. It may be a weed instead of a fish that, after all my labor, I shall pull up." Events proved that he had really hooked the largest fish in the electrical sea, for he produced a current in one coil of wire by means of a current in another coil or by a magnet, and showed that these coils could be moved mechanically in relation to each other. Thus was the far-reaching principle of induction discovered, the chemical battery



William Wallace.

replaced by mechanical force, and Davy's 2,000 "machines" reduced to one. As far as fundamental discovery could go the dynamo had been born.

From the time of Davy's experiments to the publication of Faraday's discovery in 1841 the attempts made to utilize the arc resulted in betterments in the carbon employed; and Grove and Bunsen so improved the chemical batteries that Archereau and Delieul were able to light the Place de la Concorde in Paris by means of the arc. So crude was their apparatus that they were obliged to move the carbons by hand as they were consumed. Such an ocular demonstration in so public a place could not fail to stimulate invention. The arc lamp, which was at first called a "regulator," began to take form and incandescent lamps were devised, but the lack of effective and economic means of generating electricity arrested further progress.

As a result of Faraday's discovery, Pixii, Page, Clark and others had constructed laboratory magneto-electric machines which contained the germs of the modern dynamo, but they were too crude to furnish the link needed to connect lamp and electricity in effective circuit. The first dynamo-electric generator, known as the Alliance machine, was built in 1857 to produce illuminating gas from the decomposition of water. This effort proving unsuccessful, the machine was modified to generate an alternating current for electric lighting. It was installed in a lighthouse at Havre in 1863, and in 1886 was reported as still doing good work, never having been out of order from the day it started, a record rarely equaled by machines of later make.

The Clark commutator assisted in turning attention from the alternating current to the continuous-current arc, which, by its phenomenal power and whiteness, fixed the public eye for more than a decade. The pioneer structural work of Page, Siemens, Clarke, Wheatstone and Pacinotti paved the way for the continuous-current dynamo of the French artisan, Gramme, whose machine was so effective that it marked a revolution in electric lighting and quickened invention in all branches of the art.

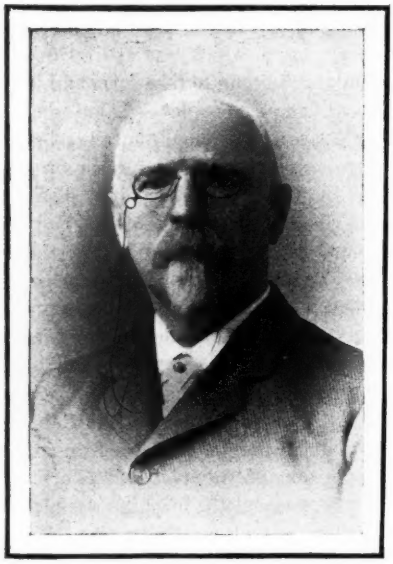
Though high-grade theoretical work has been performed by Henry, Rowland, Thomson, Kennelly, Tesla and Steinmetz, the history of electricity has usually found its pure scientists in Europe, while its practical applications have been made chiefly by a series of American inventors whose preeminence in this field is now generally recognized.

At the Centennial, in 1876, a Gramme dynamo operated a single lamp, but its rays lighted the way for the long series of inventions which have made America famous in the history of applied electricity. At the Mechanics' Fair, in 1879, Brush exhibited his continuous-current, four-lamp dynamo, the prototype of the modern 160-light, multi-circuit Brush generator. Although this plant was purchased and put

Mr. Edwin Ruthven Weeks became identified with the electric lighting industry in 1883, when he was appointed superintendent of the Kansas City Electric Light Company and put in charge of the first Thomson-Houston central station. Mr. Weeks has been connected with that company until recently and is now practicing as an electrical engineer. His status in the electric lighting industry is of the highest. He was third president of the National Electric Light Association and is not only one of the pioneers in the industry, but one of its most active members to-day.

in service in a Boston clothing house, the fact that each lamp required a separate circuit, precluded the general introduction of lamps of this type.

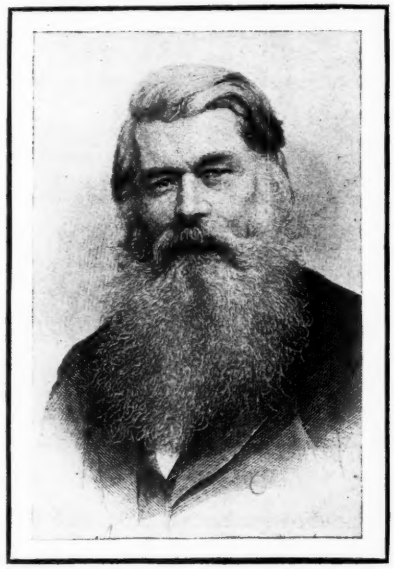
Up to this time the economic operation of more than one lamp on a circuit



Dr. Isaac Adams.

had not been accomplished. The invention of the Brush differential regulator and automatic cutout for each lamp made possible a series of several arc lamps in a single circuit with attendance only at the dynamo. Mr. Brush also early enlarged the generator to a capacity of 16 arc lamps, but for the regulation of the energy delivered to the circuit still depended upon the dynamo attendant. The completion of the dynamo as a part of a commercial system of arc lighting was found in the Thomson-Houston automatic regulator, which made it practicable to turn on or off any or all lamps in circuit without hand regulation at the machine. For the first decade, arc lighting was confined almost wholly to the two forms of constant continuous-current apparatus known as high and low-pressure series systems. A merry war was waged between the two, and it took several years to determine the smaller cost and superior commercial efficiency of the high-pressure apparatus. This system now simplified its lamps and adopted the so-called "subdivision of the arc" by means of which the quantity of current was reduced, the cost of production lessened, and the distribution extended. The work of Edison and his colaborers in the incandescent field resulted in the widespread use of the constant-potential, continuous-current dynamo, and created an imperative demand for an arc lamp suitable for this class of generators. Many types of constant-potential arc lamps appeared, which, although less efficient than the series arc, secured for these lights the safety, the facility of turning on and off, and the metering of the constant-potential systems. An increased carbon life of from 100 to 150 hours was next obtained by enclosing the arc in an atmosphere depleted of oxygen. These improvements have lessened interference with business in the rooms lighted and have greatly reduced the cost of carbons and attendance. However, the principle of the enclosed arc is now being successfully applied to series work.

The incandescent lamp did not keep pace with improvements in the dynamo. This is one of the curious inconsistencies of the story, and shows clearly that electric lighting apparatus did not at first follow a demand for a domestic necessity, but was rather the result of scientific



Joseph W. Swan.

search for electrical principles, combined with a public curiosity regarding a brilliant illuminant. The arc bedazzled observers and obscured, for a time, the more universally available incandescent lamp.

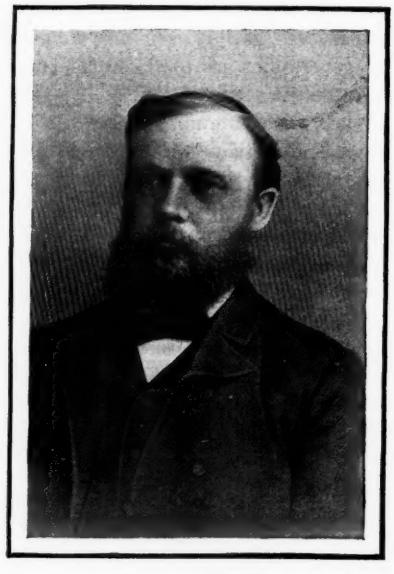
The invention of the modern incandescent lamp was based on Gray's classification of "conductors" and "non-conductors," Davy's principle of incandescence, the Geissler tube and the air pump.

The lamp began with a complicated and unsatisfactory mechanism for supplying the deficiencies of a short-lived incandescing rod, and for holding this in circuit, and ended in a simple carbon loop fastened to a simple base in a bulb of glass, and put in circuit by one of the simplest of screw sockets.

The procession of impossible lamps started with the patent secured in England in 1845 by King, acting for an American named Starr. "A pencil of carbon, platinum or other metal" was enclosed in a Torricellian vacuum with a stout platinum wire sealed in at the top. An insurmountable defect of the Starr lamp was the impossibility of sealing the platinum in the glass.

The list of impracticable lamps finds its turning point in 1867-69, in the dilettanti experiments of Dr. Isaac Adams, of Gloucester, Mass. From his work with glass and platinum was evolved a glass whose co-efficient of expansion is identical with that of platinum, making possible a stable "sealing in" and a higher vacuum.

Up to 1878 all inventors had proceeded upon the theory that an incandescing medium of low resistance was essential. In this year Lane-Fox began experiments to develop a high-resistance lamp, but did not succeed in constructing effective mechanism. In the same year Edison, under the stimulus of the possibilities developed by the Wallace-Farmer dynamo electric machine, conceived the revolutionary idea that the incandescing medium must be of high resistance, and that through this high resistance the electric current could be subdivided indefinitely. In 1879 he applied for a patent on a lamp whose filament was of high resistance carbon, and whose other characteristics were surprisingly near those of the best

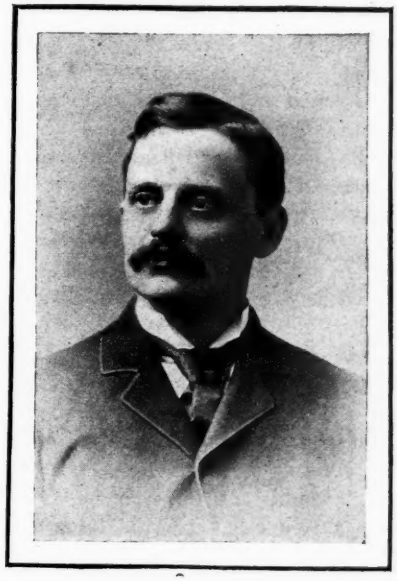


Edward Weston.

lamp of the present day. Now that the smoke of battle has cleared away, this lamp is admitted to be the commercial solution of the question of incandescent lighting.

The general public, making up its mind immediately as to whom the glory was due,

has never wavered in its recognition of service well performed by Thomas A. Edison; and the scientific student can not fail to experience an intelligent wonder that this simple American should have, almost in an instant, conceived not only the



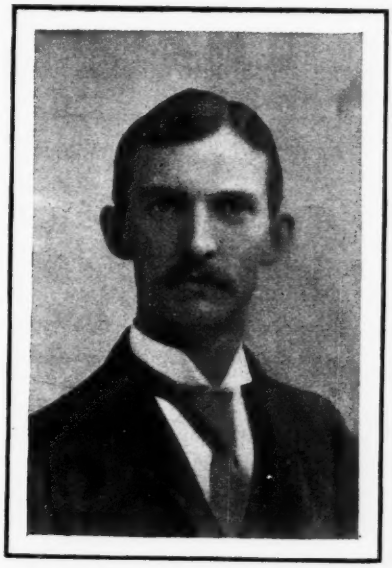
ELIHU THOMSON.

essential features of the incandescent lamp, but most of the appliances which its commercial use would necessitate.

Having determined the characteristics of the filament, Edison set himself to discover its proper manufacture, and finally selected carbonized bamboo as best adapted to his purpose. From the time of Foucault the processes of manufacturing carbon have so improved that it is now produced in any form required. The best carbons for arc lamps are made of carefully selected gas carbon, pulverized and mixed with various proportions of lampblack and tar. The paste is squirted through dies and finally baked at the highest possible temperature. Some carbons for use in positive holders have cores of carbon, borates and silicates, which prevent hissing and assist stability and conductivity. The incandescent filament is made from the purest cellulose, such as filter paper and absorbent cotton. The material is reduced to a pulp, dissolved in a suitable solution, rendered viscous by evaporation, and squirted under pressure into an alcohol bath to harden. Since the revolutionary work of Edison, improvements in the incandescent lamp have been chiefly to increase efficiency and useful life, although there have been efforts to extend distribution by means of higher voltages. Tesla's brilliant experiments with high frequencies and high potentials, and the recent work of Nernst, though extremely interesting from a scientific point of view, have, as yet, reached no important practical results in the field of incandescent lighting.

Apparatus for the production of electric light began with complicated mechanism and proceeded by slow steps through a process of elimination, resulting in a simplicity which is not the least source of astonishment to the intelligent observer. The fact is, that inventors were dealing with an unknown force and with principles not yet clearly understood or defined. The apparatus therefore embodied the unformed and doubtful mental state of its makers. On the contrary, most other important mechanical inventions, as that of printing, for instance, engaged only well known and elementary forces and therefore proceeded from simplicity to complexity, to answer complex needs.

The history of distribution dates from



OLIVER BLACKBURN SHALLENBERGER.

the early eighteenth century, when Stephen Gray classified bodies as "conductors" and "non-conductors." This classification contained the first suggestion of the transmission of electrical effects to a distance from the source of energy. But it is a far call from the "conductors" of Gray to the elaborate equipment for distributing the power of Niagara, and the three-wire system of Edison, without which the modern methods of generation and supply would give out a product of comparatively little commercial value.

While various substances have been experimented with, copper still maintains its place as the most satisfactory conductor. Its physical properties preeminently fit it for use in the construction of electrical apparatus and systems of distribution, and prevent its material deterioration by service or exposure. Advance in theoretical knowledge of the electrical properties of bodies has resulted in great improvement in construction of apparatus and insulation and arrangements of conductors. This has increased the efficiency of the station and the facility of distribution, and has greatly improved the service.

The bare wire with ground return, which was naturally first used for distribution since it already served the telephone and the telegraph, was soon abandoned through considerations of safety, and replaced by the insulated two-wire system, in use almost from the beginning. It is still employed for alternating-current work and for isolated plants. The cost of copper made this system too expensive for constant-potential continuous-current distribution where it is expedient to serve a considerable area from a single station. Edison met this economic feature with his three-wire system.

The mechanical difficulty and cost of building continuous-current dynamos, and the expense of running them, made operation and maintenance a heavy burden, and limited extensions. Stations were cumbered with small generators, belts, shafting, etc., and service was interrupted by a multiplicity of troubles. This created an urgent demand for large direct-connected generating units. When Tesla and Ferraris demonstrated that motors will work on alternating-current mains,

CHARLES P. STEINMETZ.

they paved the way for the greatest advance of the last 15 years. The beautiful and valuable system of generation and distribution which was completed after this discovery, employs the simplest, most economical, yet most powerful generators;

it transmits electricity at any pressure over a wide territory; and converts it at any point into any required pressure and quantity. The location of the primary station is no longer dependent upon the cost of copper, and therefore confined to densely populated districts, but may now be governed by considerations of public health and the sources of fuel and water supply. By means of rotaries, its product is converted into continuous current wherever required, thus utilizing accumulators and all other continuous-current apparatus. The use of the alternating current was at first opposed by many, but it is now generally recognized that the two systems are supplementary.

Costly, complicated, imperfect and perishable apparatus, unskilled attendance, and competition with a strongly intrenched illuminant having none of these incubi, created an immediate demand for appliances to reduce attendance, eliminate waste energy and material, minimize danger to life and property, and secure the fullest possible return for output. The accurate testing, measuring and recording instruments which answered this demand have contributed largely to the success of modern stations. The invention and perfection of these appliances follow the leading principles of Wheatstone, Kelvin and D'Arsonval.

Edison and Weston were pioneers in recognizing the necessity for station and service meters, and Edison early put forth his electrolytic meter which is still in use on many continuous-current systems. Other inventors recognized the need and several instruments were soon on the market. Those most largely used were the Shallenberger for non-inductive alternating-current services and the Thomson recording wattmeter which is now in general use for both alternating and continuous-current work.

The most marked characteristic of the new light is its wide range of intensity answering every requirement of illumination, from the powerful searchlight which guides the mariner to the merest speck of a light which leads the eye to the diseased spot in throat or tooth. And with that most recent and most wonderful form of electric light resulting from the researches of Rœntgen and Lenard, the ultra-violet rays are applied most beneficently in modern surgery.

Every manufacturing interest has received direct or indirect impulse from the discovery of an illuminant offering opportunity for perfect inspection, doubling or shortening of hours, and freedom from vitiated and depleted air in workrooms, while many entirely new industries have been established through its agency.

Before the introduction of electricity into woolen mills, the cloth produced in Winter was inferior to that manufactured in Summer. The unprecedented demand for engines of high economy and close regulation has stimulated improvement in steam engineering.

The decorative arts, the multiplication of shades and tints in fabric dyes, artistic illumination of interiors and a thousand other methods of appealing to the sense of the beautiful have been quickened to new life by an illuminant that counterparts daylight in its development of color effects. The extent to which the new light may be employed for fountain effects and for interior lighting and decorative work was revealed at the Columbian and Paris expositions, and will, under the able direction of Mr. Luther Stieringer, form one of the most novel and attractive features of the Pan-American celebrations.

As the glass bulb may be moved to any part of a room and fixed in any position at any angle, and as its receptacle or holder cuts off no light, it is of inestimable value in engraving, designing, carving and many other fine arts, in which the desideratum is a brilliant speck of light at exactly the right point. Time does not suffice to enumerate the multitudinous advantages of the new light, such as its adaptability to mining, navigation, photography, etc. Among its minor advantages must be mentioned the facility with which it may be turned on or off by pressing a button.

Perhaps its most vital characteristics are its absolute healthfulness and its safety. Gas, though hailed as a blessing, brought with it a tremendous incubus of human ills which the difficulties of production and distribution had largely prevented in former methods of illumination. The electric light, on the contrary, combines with even greater facilities of distribution, an absence of odor, heat and by-products which not only poison the air but ruin clothing and draperies, and soon render futile the most delicate and elaborate decorations.

An eminent New York oculist says, "Its light is absolutely steady, and it produces the maximum illumination with the minimum heat. Out of the 1,100 persons examined who work under the incandescent light, no case of injury to the eye was found; in fact, those who had formerly suffered from errors of refraction claimed that their sight was improved." The value of these qualities in an artificial light needs no explanation. When we consider the further fact that the preservation of books and painting requires pure air, the need in our homes, libraries and art galleries of an illuminant which does not vitiate the atmosphere becomes still more apparent.

It is probable that the general public does not appreciate the safety of the new light, yet safety is one of its strongest recommendations. It does away with matches and an open flame, it can not explode, and if the lamp breaks the current is arrested and the light goes out. The most striking testimony to this feature was given at the congress of railway industries held at the Paris Exposition. In two able reports as to methods of train illumination, the unanimous conclusion of the gentlemen who made the investigations upon which these reports were founded, was the absolute safety of the electric light.

As a moral force this light has proved an invaluable agent in maintaining order and preventing crime. When streets were first lighted, crime immediately decreased. As methods of illumination improved this decrease became greater and greater, until its maximum has been reached by the use of the powerful arc. The most dangerous and abandoned sections in many of our great cities have been rendered safe and comparatively pure by means of this light. "In preserving the peace and safety of our citizens," says a leading New York paper, "it is second only to the most efficient police force."

Electric light must be regarded as one of the world's conveniences, and like all conveniences it yields to labor another industry—an industry that requires intelligence and judgment. It is a fact that electrical employés as a class are superior in this respect to the operatives in other trades. In most of the latter the best has been attained, but here there is an ever widening field of investigation that spurs the humblest worker.

Most inventions of great commercial value in mechanics supplant some form of industry, and often throw many out of employment and render worthless a large amount of costly apparatus. The gas interest has felt that the electric light was such an invader, but this has not so far proved to be the case. It is a fact, growing into general recognition, that while gas has lost its position as the leading illuminant it is the fuel of the future.

This new industry has involved the investment of many hundreds of millions, and furnished support to hundreds of thousands; but, great as has been this achievement, there is little doubt that the most valuable results of electrical invention have come from a quickening effect upon all branches of science, both pure and applied, and all systems of thought and philosophy.

The Rise, Growth and Present Extent of the Independent Telephone Movement.

By James M. Thomas.

TO WRITE a complete history of the Independent Telephone Movement from its inception to the present time would require more time and space than has been allotted to me, besides it would be of no great value and of very little interest to the average reader, to go into the full details, giving proper credit to all who are deserving of it. With a correct chronology of the different events of interest which go to make up the history of this movement, it is to be presumed that if we could trace the movement to its very fountain-head, some one person, as is always the case in all historical events, is worthy of more renown than others in the inception of this revolution in the telephone world.

The beginning of this revolution can truthfully be described as a spontaneous uprising throughout the United States, after the expiration of the basic patents, to cheapen and to enlarge the facilities of the telephone, and as this came about in so many different places under the leadership of many different people, it would be difficult, without great research, to find the Moses who first conceived the idea of leading us from the wilderness of high prices and few telephones to the "promised land" of reasonable prices and many telephones. However, there was an organization in the city of New York which seems to have preceded all others, whose object was to manufacture and install interior telephone systems, known as the Interior Telephone Manufacturing Company. This company was organized and managed by Frank R. Colvin, now of the Western Electric Company, in 1892, and started out in a thorough way to supply a demand at that time wholly unprovided for by the American Bell companies—that for the installation of interior telephone systems for the convenience of people occupying the same buildings. While the prospects of this organization were fair, it enjoyed only a short existence. We find that in a short time its founder and manager was employed by the Western Electric Company at a handsome salary under a long-term contract, and the organization then passed out of existence.

A little later we find an organization, known as the Stromberg-Carlson Telephone Company, organized in the city of Chicago for the purpose of manufacturing what is known as the "magneto transmitter." This organization installed a few telephone exchanges in different parts of the country, using in most instances a switchboard which was made by the Utica Fire-Alarm Company, of Utica, N. Y. I believe that Messrs. Stromberg and Carlson had both been workmen in the factory of Ericsson & Company, in the city of Stockholm, Sweden, and had been in the factory of the Western Electric Company, of Chicago, for some time prior to the organization of this company in opposition to the Bell interests.

Shortly after the organization of this company, Jas. E. Keelyn and Geo. F. Stitch organized the Western Telephone Construction Company, of Chicago, its object being the construction of telephone exchanges, and began that work upon a larger scale than had been attempted by any other organization at that time. The magneto transmitters, manufactured by the Stromberg-Carlson Telephone Company, and the switchboard, made by the Utica Fire-Alarm Company, were used in their construction in the first instance. Soon after they enlarged their facilities and manufactured their own telephones and switchboards, and at about the same time the Stromberg-Carlson Telephone Company commenced to manufacture the microphone.

Prior to this time, however, what was known as the Harrison Telephone Company had been organized and was looked upon more as a stock jobbing organization than anything else, but in addition to large sales of stock, which was accomplished by the use of the names of prominet men in different parts of the country, they installed a few telephone exchanges. This organization soon passed out of existence and the exchanges that they had equipped struggled along. By replacing their old telephones, which had been used in connection with the very crude switchboards of different makes, they have succeeded, in most instances, in building up a profitable and flourishing business.

Judge James M. Thomas before his election as president of the Independent Telephone Association of the United States of America, had practiced law for several years in Ohio, and was a well-known and active member of the bar of that state. Judge Thomas became prominently identified with the independent telephone movement and was elected to the presidency of the National Association at its first meeting—an office that he still holds. He has been a prominent figure in the establishment of independent telephony and in the conduct of the litigation that has arisen in connection with this development of the art.

The latter part of 1893 and the early part of 1894 found several operating companies in existence, formed by enterprising spirits in a few of the smaller cities, who desired better telephone facilities at more reasonable prices. While they fully realized that there was some danger of personal loss to themselves, they proceeded with their work and were very much surprised when they found the great demand that was made upon them for telephone service.

In the central states this movement seemed to take deep root, and the close of the year 1894 found very many flourishing independent telephone companies operating exchanges in this territory. In the early part of 1894 P. C. Burns organized what was known as the Kokomo Telephone Company, for the manufacture of telephones at Kokomo, Ind. He soon showed the energy that has since characterized his efforts in the manufacturing line and was soon among the leading spirits of the independent telephone movement.

Geo. W. Beers, of Fort Wayne, Ind., entered the field as a promoter, confining his efforts in the first instance to the western portion of Ohio and the eastern portion of Indiana. Elsewhere in Indiana an organization was perfected by Hon. Hugh Dougherty, of Bluffton, known throughout Indiana as a leading politician and banker.

Hon. H. D. Critchfield and Frank L. Beam, of Mount Vernon, Ohio; W. S. Weiant and Jas. K. Hamill, of Newark, Ohio, and Hoyle & Scott, of Cambridge, together with many others whose names can not be mentioned, commenced to build exchanges in Ohio.

A little later the Detroit organization was formed, headed by Chas. E. Flowers. This organization undertook the task of building an exchange in the city of Detroit, which was the largest undertaking at that time conceived by the independent telephone workers. Naturally their development was watched with a great deal of interest. The history of this organization having been completed is better known and understood than the history of any other independent organization.

Later Geo. W. Beers organized a company to work in Fort Wayne, Ind. This plant and the Detroit plant were completed and put into operation about the same time. This made the smaller companies feel encouraged, and the movement from this time grew with great rapidity. Prior to this time, in the Spring of 1894, after a dozen companies were well under way in constructing their plants in the state of Ohio, on account of the threats

that were being made on the part of the Bell companies, a meeting of half a dozen men was held in the city of Newark, at which meeting the idea of organization was conceived, and it was agreed to call a meeting in the city of Columbus a little later, for the purpose of organizing an association of independent telephone people in Ohio. In accordance with this agreement a meeting was called for the city of Columbus the latter part of April, and the first independent telephone association was organized under the name of "The Independent Telephone Exchange Association of Ohio." Some of the men who attended this meeting have become well known in the independent telephone world, and from this organization the idea of the national organization, which followed in June, 1896, was conceived.

Prior to this time, Burt Hubbell and J. G. Ihmsen had organized the Keystone Telephone Company, of Pittsburgh, and had commenced to complete exchanges in the western part of Pennsylvania, also the manufacture of telephone apparatus. The McKeesport exchange had been completed by Mr. Hubbell and was so successful that it encouraged the movement all through the western part of Pennsylvania.

Shortly after the organization of the Ohio association it was agreed that a joint committee from Ohio, Indiana and Pennsylvania be formed for the purpose of guarding the mutual interest of the three states. This committee consisted of one representative from each state, namely: Geo. W. Beers, of Ft. Wayne, Ind.; Burt Hubbell, of Pittsburgh, and the writer. This committee had power to call to its assistance any persons they deemed valuable for assistance in any part of the work, and out of the meetings of this joint committee grew the preliminary meeting which led to the national organization, the first preliminary meeting being held in the city of Chicago in May, 1896. This fixed the time and place of meeting to complete the organization in the city of Detroit, June 22, 1896. The history of this organization is too well known in telephone circles to require repetition at this time, as its officers and active members have become well known throughout the telephone world and have proven the bulwark of the independent telephone movement. About this time the movement seemed to have taken a stronger and deeper root, and spread with a rapidity that has not been equaled in any other enterprise this country has ever seen. New manufacturing companies sprung up, and exchanges were begun in almost every state in the Union.

At this time the Bell interests became alarmed and sought in every way to throttle the movement. The press, to a certain extent, was, through the Bell influence, opposed to the movement, and subscribers of independent telephone service, as well as stockholders and promoters, were continually warned by notices sent out that the American Bell Telephone Company was the owner of letters patent No. 463,569, issued to Emile Berliner, and that infringers of that patent would be held liable for their infringement.

In spite of the many articles published in the newspapers of these notices and warnings, the movement continued to grow until it assumed a proportion that attracted the attention of capitalists and promoters of large enterprises, who, after investigation, were satisfied to enter the field.

Milo G. Kellogg, who for many years had been one of the leading inventors of switchboards and appliances for the Western Electric Company, and who was a member for several years of the board of directors of that company, "saw the handwriting on the wall," and organized the Kellogg Switchboard and Supply Company, which organization undertook the installation of large switchboards.

M. J. Hanford in the meantime had organized the Kinlock Telephone Company, of St. Louis, which contracted with Mr. Kellogg for the installation of his system. This was by far the largest undertaking at that time, Mr. Hanford having in his organization the wealthiest and most influential men of St. Louis, and with the ingenuity of an able corps of men to work in connection with the Kellogg Switchboard and Supply Company, he succeeded in successfully installing and putting into operation this very large and complete telephone exchange.

Honorable S. P. Sheerin had completed his Indianapolis organization about this time. Geo. R. Webb had purchased the old franchise at Baltimore and Pittsburgh and organized the Maryland Telephone Company and the Pittsburgh & Allegheny Telephone Company.

Henry A. Everett, E. W. Moore and associates, of Cleveland, purchased a franchise which had been granted to the Home Telephone Company, of Cleveland, Ohio, and organized the Cuyahoga Telephone Company, and later the United States Telephone Company. Samuel E. Wayland, formerly of Cincinnati, Ohio, has been made manager of the People's Telephone Company, of Wilkesbarre, Pa., and these companies all contracted with the Kellogg Switchboard and Supply Company for their installation. Thus the work proceeded.

This was more encouraging to the smaller interests throughout the country, and they began to multiply much more rapidly than heretofore, until a point was reached where it seemed necessary for something to be done by the Bell companies to frighten capital from this field. The thing conceived and carried out was the purchase of the property of the Detroit Telephone Company and the lines of the New State Telephone Company, owned and controlled practically by the same men, under the leadership of Honorable Chas. E. Flowers, of Detroit, Mich., by the Erie Telephone Company, a licensee of the American Bell Telephone Company. With glowing headlines, the press of the country announced this sale as the beginning of the end of the independent telephone movement, and much was said about the effect that it would have upon the movement. Those most interested watched with great interest to see what effect, if any, this sale would have, and they soon found that it did not check the progress of this movement, except perhaps in the state of Michigan. The neighboring exchanges for a time felt anxious.

In the early history of the movement in Michigan the most important undertaking in the state was the organization of the Citizens' Telephone Company, of Grand Rapids, organized by E. B. Fisher and J. B. Ware and their associates, who were strong through their local influence and their financial ability. This organization had succeeded in possessing the telephone field in Grand Rapids prior to the installation of the Detroit exchange, and from that time this organization has proved a great success financially and in every other way. These men, together with J. R. Johnson and his associates, of Saginaw and Bay City, Mich., and the smaller interests throughout the state, outside of the Detroit people who had sold to the Erie, immediately began new warfare by inducing the United States Telephone Company to build through the state of Michigan for their connections, a trunk line connecting them with the Ohio system. This work, which is now going on, accomplished the thing desired and there has never been a time that the Michigan independent telephone interests felt more confidence than now.

J. C. Hubinger, of Iowa, had begun operations in a small way, and having been successful in his early undertakings, became encouraged to the extent that he undertook the building of independent telephone exchanges in Minneapolis and St. Paul, which have been completed and equipped with Stromberg-Carlson apparatus.

Smaller companies throughout the South and West built exchanges in a greater part of the cities. Two years ago the attention of the Eastern people was attracted to this movement in a way that led to many organizations. Among the early days of the movement a great many independent exchanges had been completed in the East, especially in western Pennsylvania, Virginia, Maryland, New Jersey and some in New England. Richmond, Va., after a hard fight in the courts and municipal councils with the Bell company, succeeded in establishing a flourishing independent telephone exchange in that city. Norfolk, Va., Wilmington, Del., and Newark, N. J., had successful independent exchanges.

The movement had taken deep root in the anthracite regions of Pennsylvania. Senator C. W. Kline and Sam E. Wayland are still at work developing that field and are very successful. The Lackawanna telephone company, under the management of Sam E. Wayland, is now building in Scranton, Pa. and the Interstate Telephone Company, under the direction of Senator C. W. Kline, are busy building long-distance telephone lines throughout Eastern Pennsylvania.

The Massachusetts Telephone and Telegraph Company, of Boston, entered the field after securing a franchise in the city of Boston, together with many others throughout Massachusetts.

The Knickerbocker Telephone Company of New York city was organized and undertook the development of New York.

Men who have been successful in combining traction and other interests conceived the idea that the Independent Telephone movement furnished a new field for their energies and powers, so about two years ago the Telephone, Telegraph and Cable Company of America, was organized in New York city, the organization being announced in the press as a great aggregation of capital ready to invest in the independent telephone field. Geo. W. Beers, of Fort Wayne, Ind., was identified with this movement, and being prominently known throughout the country as one of the leading independent telephone men his name in this connection added to the belief that there was good to come to the independent movement through this organization.

The announcement then came, after the purchase of the Detroit properties by the Erie, that this new organization had gained control of the stock of the Erie properties, which has been the source of a great deal of doubt on the part of the independent telephone people that this organization was to be thoroughly independent of the Bell. The work of trying to form a combination between the Erie and some of the larger independent telephone companies was begun, so far without success. Others who have been successful in combining similar properties owned by different organizations, were attracted to the field and much work of this kind is being done by people of ability in this line.

While this chapter of the independent telephone movement is of the present, and of course has interest for those who have invested their money in this enterprise, it has not attracted enough attention to influence the movement to any extent, as the work of building exchanges and toll lines proceeds without interruption. As to whether or not these men will succeed in perfecting their combinations is a matter that does not belong to the province of this article; as it is in the future, any statement could only be in the nature of a prophecy. The "Old Guard," as those who have become most prominent in this movement are generally termed, are still at work, faithfully carrying out their intentions of making this movement one of great moment to the commercial interests of this country.

Those of large financial resources, who, after thorough investigation, have chosen this as a profitable field of investment, are not excited on account of these proposed combinations, but, with faith characteristic of large investors, are continuing to extend their properties, developing every new possibility for increasing their business. The workers throughout the country have shown remarkable aptitude in the development of these new resources and find much of value heretofore overlooked by people who have been for many years engaged in this business.

As to the extent of this movement, it is difficult to find an exact measure for it in figures, as the movement has been so rapid that the compilation of figures made at any period of time in a few months gives a very poor conception of its then extent.

It can be said with truth that no investment has found a place for so many dollars as has the independent telephone movement in the same length of time, and that no business has shown greater returns for the investment, as a whole, at a similar stage of the investment.

The records of the Independent Telephone Association of the United States of America show that there are independent telephone exchanges in operation in the following states and territories:

Alabama,
Alaska,
Arizona,
Arkansas,
California,
Colorado,
Connecticut,
Delaware,
Florida,
Georgia
Hawaii,
Idaho,
Illinois,
Indiana,
Indian Territory,
Iowa,
Kansas,
Kentucky,
Louisiana,
Maine,
Maryland,
Massachusetts,
Michigan,
Minnesota,
Mississippi,
Missouri,
Montana,
Nebraska,
New Hampshire,
New Jersey,
New Mexico,
New York,
North Carolina,
North Dakota,
Ohio,
Oklahoma,
Oregon,
Pennsylvania,
South Carolina,
South Dakota,
Tennessee,
Texas,
Utah,
Vermont,
Virginia,
West Virginia,
Wisconsin.

In several of the states the number of independent telephone exchanges exceeds that of the Bell. This is true in Pennsylvania, Ohio, Indiana, Illinois, Michigan, Wisconsin, Iowa, Missouri and Kansas, and perhaps in other states.

The investment at this time, from the best information obtainable, exceeds $100,000,000. The number of telephones in operation is estimated by those who are in position to form an idea of the growth at 1,250,000.

The Edison Illuminating Company's First Plant.

By Charles S. Bradley.

The station was located at 257 Pearl, near Fulton street, New York city, and was the first large plant for the supply and distribution of electricity for any and all purposes, within a defined district, in the world. The district was bounded by Spruce street, the East River, Wall and Nassau streets. There were two extensions, one to the Stock Exchange and another to J. P. Morgan & Company's bank at the corner of Broad and Wall streets. After the plant had been in operation some time extensions were made to Broadway, but these extensions were not in the original design. For boldness of conception and execution this has always seemed to the author to have been one of the greatest engineering feats on record. One should remember that most of the problems present in this undertaking had never been attempted before. The preliminary plant constructed by Mr. Edison at Menlo Park demonstrated that such a system was feasible, but the conditions of city lighting and power distribution presented many new and interesting problems. The anxiety of those who had the responsibility can scarcely be appreciated now when there are so many electrical installations of much greater size, and when these difficulties have been solved and have become an every day affair.

All was new—high-speed engines, direct-coupled dynamos (at that time the largest in the world), underground system, means of insulation, fuses for protection of the system, meters, and methods of inside wiring. Mr. Edison's character commanded our highest admiration. He was patient, kind, enthusiastic, ever ready to advise and discuss any new and intricate problem; never discouraged at what seemed to some of us insurmountable obstacles, and after visits which occurred often and many times lasted all night, we felt that we had imbibed that indefinable something which great leaders impress upon those about them.

The work of installation was divided into three departments, station equipment, underground conductors and inside wiring. Mr. Chas. L. Clark was the chief engineer, and the underground conductors were laid by the Edison Tube Company, of which the late Mr. John Kruesi was superintendent. The testing and inspection on behalf of the illuminating company was intrusted to me, the inside wiring being under the management of Mr. Edwin T. Greenfield. The inside wiring was begun about five months before the underground work. I began work under Mr. Greenfield, July 5, 1880, and had a rare opportunity to see the difficulties in the department of inside wiring, as I was

Mr. Charles S. Bradley has been connected with the electrical industry since the establishment of the first central station in Pearl street, New York city, where he occupied the position of inspector. Since that time Mr. Bradley has done considerable work in electrochemistry, having invented numerous forms of electric furnace, as well as in alternating-current work, in which he was one of the early pioneers and to the development of which he has contributed largely, many patents on polyphase apparatus and systems having been granted to him.

appointed, much to my disgust, time-keeper ("spotter," the men called me). This position required much tact to keep from being either in disgrace with the employé or employer. It was, however, so important to become connected with this field of work that one could not choose the round of the ladder on which to get a foothold but must needs take the one he could get.

There were 40 men engaged on inside wiring and a motley crew were they. Some were carpenters, some were telephone linemen, some were men of aspiration and some trusted to the ravens, but not one understood a multiple arc system of distribution of electricity. They put the wire up with moulding and if the wires were crossed, so that the screws would not draw the moulding to its place, they used the hammer freely, and it is needless to say that much had to be taken down again. The ambitious, feeling their lack of knowledge, finally signed a petition which Mr. Greenfield presented to the officers of the company to have an evening school. Our teachers were Messrs. Edward H. Johnson, Francis R. Upton and others. This was the most interesting school that many of us ever attended, struggling with the actual problems every day and the theoretical explanation one evening in the week, stimulated by the desire to succeed in that great industry which was then casting its early morning beams, we let not a word escape us.

During the Fall of 1881, work was commenced on the south side of Peck Slip to lay the underground conductors near the curb. A test line was run over the buildings to the cellar at 257 Pearl street, where there were installed 250 gravity cells and a 1,500-ohm Thomson galvanometer, in the hope that very high insulation tests could be made; but after three weeks of futile labor these tests were abandoned. A portable dynamo driven by hand and a delicate fibre-suspension galvanometer were obtained; with these fairly good tests could be obtained. It is to be remembered that no portable instruments were in existence then.

In the early part of November, 1881, I was placed in charge of this testing with instructions to carefully inspect every joint at each step in the laying. The conductors came to us in twenty-foot lengths, incased in wrought-iron pipes. The conductors themselves were in cross-section, each a segment of a circle; two of these, the positive and negative, were held in place by prepared pasteboard washers spaced at from four to six inches apart. The washers were then tied with string and had besides the holes for the conductors, smaller holes to allow the insulating compound to completely fill the spaces inside the tube. The conductors projected through a specially prepared wooden plug about one and one-half inches. The conductors of one length were united to those of the next by spring couplings soldered; then a coupling box was placed around the joint and filled with insulating compound. The lengths came to us on the street in perfect condition, but with careless soldering and a free use of soldering acid our troubles were without end when we came to test. As much of the work had to be done at night on account of the traffic on the streets, it can be imagined that the lot of the inspector was not a happy one on a cold Winter's night. To add to our troubles the feeders had two small wires besides the main conductors, which were intended to transmit back to the station an indication of the pressure at the point where the feeder joined the network, and these little wires were prone to break off close to the wooden plug in the end of the tube. When this happened the inspector had to lie down in the trench, dig out the wood around the wire and make a splice.

The Winter passed and with the Summer we made more rapid progress. Mr. Edison was very much interested to find out whether we could locate a cross or ground on such a system. One night we had a cross that was very difficult to locate, so we spent the night hunting mostly in the station with instruments. We found the resistance was about 170 ohms, but what part of the district it might be in was beyond our appliances. Mr. Edison said, "Bradley, I think it is a lamp." At this time the system was not yet complete and no customers were connected, but the next day in going the rounds I went into the cellar of Winslow, Lanier & Company's bank and found a meter had been installed; the meter appeared innocent enough but aroused suspicion, and on opening the door the thermostat was found *closed,* so that the lamp which was intended to keep the meter warm in cold weather was on the system and Mr. Edison was right in his conclusion.

When the sixteen miles of underground conductors were all complete and connected up the resistance of insulation between conductors was 52,000 ohms, which was high when we take into account the large size of the copper. The generating plant was not ready as soon as the outside work, and it was a matter of great curiosity to me to know if it could be expected to work as planned. There was in the cellar of the station a small fifty-five-volt lighting machine which could no doubt be connected by wires to the system, but the engineer must not know of it. After a careful survey a place for connection was found and wires prepared, but when ready to join the wires to the conductors a soliloquy occurred: "If one wire is touched to one conductor what will happen? Ah! a small spark! If the other wire is touched to the other conductor what will happen? Ah! a small spark! If both wires are each touched to a conductor what will happen? Ah! two small sparks! Nothing serious!" The reader will say, "Why, of course," but he should remember how much more familiar with these arts we are to-day. At that time it seemed to the imagination like hitching a mouse to a truck in hope of having him move it.

After connecting this wee bit of a dynamo to all these tons of copper the next question was, "What is the effect outside?" We take a fifty-five-volt lamp, repair to the cellar of Morgan & Company's bank, asking ourselves all the time we are on our way, "Will it light up? It ought to, it ought to, but will it?" Arriving at the meter we hang the lamp on the terminals and it bursts into a beautiful glow. Hurrah! The first lamp ever lighted from a central station supply system.

Some time in the late Summer of 1882 one of the so-called Jumbo dynamos with its engine was in position and ready to run. One day we received notice that Mr. Edward H. Johnson would be at the station to connect the system of distribution to the bus-bars and these to the dynamo to see how the whole might work together. It was a beautiful but warm Summer afternoon. Switches were provided for connecting the dynamo to the bus-bars, but the couplings for the feeders were crude devices, composed of a brass arm about ten inches long. As Mr. Johnson closed each one of these he severely criticised the designer, asking who was entitled to the honor; but no one came forward to lay claim to it and perhaps no one knew, but at last all was connected and we who were present drew a long breath and turned our attention to the commutator and brushes of the dynamo to see what might happen. All went smooth and our hopes and confidence rose higher and higher as the minutes passed until ten, then twenty and finally the half-hour mark was past, when a man came in under much excitement saying that horses were

being shocked by leaking electricity and were jumping and tearing around in Nassau street, near Ann. Mr. Johnson said, "I think you had better shut down."

That night we had our first experience in "bug hunting," and it is safe to say that we found one. The next day one of the illustrated papers had a cartoon showing a vender's horse running away, scattering his wares in all directions.

Many operations that seem so simple now were not even thought of in those days or if they were the apparatus was not constructed in such a way as to permit of their being executed; for instance, it is an easy matter now to connect in an additional dynamo or cut one out, but not so then. There were no station voltmeters nor ammeters, no way of telling when a machine was at proper voltage to be thrown in. Just here might be mentioned an illustration of Mr. Edison's bold and practical way of accomplishing results. He had a bank of 1,000 incandescent lamps placed in the loft and arranged for connection with the bus-bars in convenient blocks so that the load could be gradually placed on a machine or taken off at will; this answered for testing and for connecting a dynamo while it was fully loaded, after which the lamp bank was switched off in sections.

Mr. John W. Lieb was at this time the electrical engineer of the station, with Mr. W. D. MacQuestion as assistant. All went well until it became necessary to add another dynamo machine, when it was found that it was almost impossible, with the conditions as they then existed, to operate two of the direct-coupled machines in multiple arc. The dynamos were simple shunt-wound machines, the governors were not extremely sensitive and when two machines were placed on the circuit they were in unstable equilibrium so that the load was constantly shifted from one to the other with fireworks at the brushes. Mr. Edison's struggle with this problem was very interesting. He tried every imaginable experiment to get the machines thrown in together on the circuit, but no ingenious combination would seem to accomplish the result. This problem was finally overcome by regulating the electromotive force at the brushes.

Early in September, 1882, one dynamo was started and put in connection with the system of conductors. The first lamps were turned on by Mr. Edison in J. P. Morgan & Company's bank one afternoon after banking hours. As nearly as can be remembered there were present besides Mr. Edison, Mr. Morgan, Mr. Edward H. Johnson and Mr. Sigmund Bergmann. As Mr. Edison was about to close the switch a bet of $100 was made between Mr. Edison and Mr. Johnson, the latter betting that the lamps would not light up and Mr. Edison that they would. Mr. Edison won the money. The large electrolier was aglow and the scene left an abiding impression.

Development of the Use of the Storage Battery in the United States.

By Charles Blizard.

TO DO JUSTICE to the subject of the development of the use of the storage battery in this country requires more time than you have allowed me. The brief sketch which follows is an outline that can undoubtedly be enlarged upon by many readers of the REVIEW. It is quite possible that there were battery installations made prior to the dates given, but, if so, information concerning them is not obtainable at this time.

The history of the development of the storage battery, beginning with the experiments of Gautherot with silver or platinum electrodes in 1801, those of Ritter with gold wire in 1803, Schoenbein's with peroxide of lead in 1837, Grove's with the gas battery in 1842, Plante's with "formed" spiral plates in 1860, Metzger's, Faure's and Brush's with applied active material, 1879 to 1881, and on through the succeeding years to the present time, has been so exhaustively written up that detailed repetition is unnecessary.

The advances during the past eight years in the art of producing, and in the introduction of, a commercially practical storage battery in this country have been remarkably rapid and are well known to those who have followed the progress of matters electrical.

The records available indicate that the first battery for central station service was installed in Phillipsburg, Pa., in 1885. This installation was followed by central station batteries at Haverford and Holmesdale, Pa., in 1886, and at Allentown, Pa., in 1889. In 1890 the Germantown Electric Light Company, Germantown, Pa., installed a small battery on its three-wire system. This battery was operated until 1894, when it was displaced by a battery having a capacity of 2,000 ampere-hours. In 1893 the Edison Electric Illuminating Company, of New York, put into operation in its Fifty-ninth street station a storage battery of the Crompton-Howell type, manufactured in England.

The first installation of importance in this country of a modern type of storage battery for central-station service was that of the Edison Electric Illuminating Company, of Boston, who put into service in March, 1894, a battery of German manufacture. In June, 1895, the company installed a second battery of the same type, and in August, 1896, put into operation its first battery manufactured in this country. This installation was followed by others in 1897, 1898 and 1899, and the company is now operating eight batteries.

In 1895 the Edison Electric Illuminating Company, of New York, equipped its Twelfth street station with a battery of home manufacture, and in 1896 installed a duplicate of the battery in its Bowling

Mr. Charles Blizard entered the electrical field in 1892, taking the secretaryship of the Franklin Electric Company, whose office and works were in New York. As secretary of this company he not only took care of the selling, office and financial work, but also worked in the shop, making plates, running the dynamo, etc. In connection with the electrician of the company he spent several months in Washington, in the Winter of 1892 and 1893, testing the Franklin accumulator for traction work. In October, 1893, he became connected with the Electric Storage Battery Company, spending the last two or three months of the year in giving the business a start in Chicago. Early in 1894 he opened a New York office for the company, and had charge of the New York territory until December 31, 1899, when he moved to Philadelphia to take the position of manager of the sales department. Mr. Blizard has followed very closely the development of the storage battery in this country, and has been more or less intimately connected with the introduction of the modern type of cell.

Green station. Other plants were installed by this company in 1898, 1899 and 1900, and it is now operating on its system a total of thirteen plants.

In November, 1895, the Lawrence Gas Company, of Lawrence, Mass., installed a battery having a capacity of 137 kilowatt-hours. Other Edison companies soon adopted the storage battery, and all of the largest stations are now equipped with accumulators. The aggregate capacity of the batteries in operation in central station service is approximately 80,000 kilowatt-hours.

In 1893 a battery of 300 100-ampere-hour cells was installed on a trolley system at Dover, N. H., the battery furnishing all the energy required to propel the cars up a steep grade. The earliest installation of a railway battery, now in service, was made on the lines of the Merrill Railway and Lighting Company, Merrill, Wis., in February, 1895, the plant having a capacity of 200 kilowatt-hours. The next railway plant of importance was that installed for the Union Traction Company, of Philadelphia, on its Chestnut Hill division in 1896. The opportunities for the profitable use of storage batteries in connection with electric railway systems were so marked that the results obtained from these plants were followed with keen interest. From this beginning, the application of storage batteries to trolley systems has grown to a total battery capacity of 85,000 kilowatt-hours.

The most recent phase of the development in this field is shown in the operation of batteries in connection with rotary converter substations on long lines, one 90-mile road in Indiana having in service nine batteries.

One of the early practical uses of accumulators in America was for train lighting. In 1882 a few cells were imported from France and installed on one of the Pennsylvania Railroad Company's cars. While the experiment was not successful, it led to others, from which were developed the present system of electric train lighting, in which there are in operation approximately 9,000 cells. It is probably safe to say that in no other field in this country has the storage battery been used so uninterruptedly and for so many years as in train lighting.

One of the earliest applications of batteries was in connection with isolated lighting plants. Numerous experimental installations were made, and many claims were proven untenable in this class of service. The experience gained from these installations has been an important factor in the development of the modern type storage battery. The first plant of this character concerning which information is available at this time was installed in Baltimore in 1883 by the late A. H. Bauer. The battery consisted of E. P. S. cells, imported from England, and was used for incandescent lighting in two or three stores adjacent to the location of the battery. In 1885 the late W. W. Griscom installed a battery of E. P. S. cells in his residence at Haverford, Pa. This battery was displaced in 1888 by cells manufactured in this country. In 1885 Mr. Charles F. Brush installed at his residence at Cleveland a battery charged by a windmill-driven dynamo. Plants were installed in the residences of Governor Morton at Rhinebeck in 1887; A. H. Postel, Lansdowne, Pa., 1888; A. J. Cassatt, Haverford, Pa., 1889. At about this time a plant was put in for the Woman's Reformatory, South Framingham, Mass. This is believed to be the first instance in this country of the use of a storage battery by a public institution. Among the first office buildings to be equipped with storage battery auxiliaries were those of the Provident Life and Trust Company, 1887; Pennsylvania Railroad Company, 1889; Land Title and Trust Building, Brown Brothers and the American Fire Insurance Company's building, 1890, all located in Philadelphia. One of the early battery plants which will be remembered by many readers of the REVIEW was that of the Electric Club, New York; this battery was put into service in January, 1888. There are now in operation in this country in isolated lighting and power plants between 350 and 400 batteries, having an aggregate output of from 17,000 to 20,000 kilowatt hours.

Storage battery traction was another tempting field, in which the hopes of many of the early inventors were buried. Experiments were made in New York in 1888, 1892 and 1895; Beverly, Mass., in 1889; Brooklyn in 1890; Sioux City, Philadelphia, Dubuque (Iowa), and Chester (Delaware), in 1891, and in Washington in 1890 and 1893. The failures of many of these trials were attributable to the impracticable conditions of service demanded. There are now in successful operation about 50 storage battery cars.

As a sequence to the results obtained from the storage battery in other fields, the United States Government adopted it for fortification and coast defense work, and put down several installations in 1896. In that service there are now about 110 plants, with a total capacity of approximately 4,000 kilowatt hours.

In 1892 the Stock Quotation Telegraph Company, New York, operated its ticker service from a storage battery circuit. In January, 1894, the Postal Telegraph-Cable Company displaced the gravity cells in its Baltimore office with accumulators. The predicted advantages to be gained by the substitution were demonstrated, and the Postal company made its next storage battery installation at Albuquerque, New Mexico, in the latter part of 1894. The first installation made by the Western Union Telegraph Company was in October, 1894, on the lines of the Central Railroad of New Jersey.

The adoption by the telephone companies of the common battery system opened up a wide field for accumulators. In this service a battery was used by J. J. Carty in the first practical demonstration of the system, made by him in New York in 1888; and the first battery for commercial service was installed by the Chicago Telephone Company in 1889. The use of batteries in telegraph and telephone work has grown rapidly, and there are now between 23,000 and 25,000 cells in these services, the cells on telegraph lines doing the work of approximately five times their number of gravity cells.

In 1889 the yacht Alva, owned by W. K. Vanderbilt, was equipped with a storage battery. There are now about 75 yachts carrying batteries for lighting purposes.

The earliest use of accumulators for the propulsion of launches was by Reckenzaun, who built his launch, the Magnet, in 1888. Colonel J. J. Astor placed the order for the first private launch in 1892, at which time the electric launch business may be said to have been started in this country.

Professor Tuck, who imported a battery from Scotland in 1894, was the pioneer in the use of accumulators in submarine boats; it was not until 1898 that the Holland submarine torpedo boat, equipped with batteries of home manufacture, was launched.

While numerous experiments had been made with storage batteries for vehicle propulsion prior to 1894, authorities give that year as the date of the first practical application. The progress that has been made in the operation of storage batteries in electric vehicles is so recent as to be fresh in all minds.

The earlier chapters of the history of the storage battery in this country contain the records of many failures, and the position batteries now fill in the field of applied electricity is due to that quality of ability, courage and faith which forces victory from apparent defeat.

The Early Days of Electric Lighting.

An Interview with Mr. George W. Hebard.

MR. GEORGE W. HEBARD, vice-president of the Westinghouse Electric and Manufacturing Company, was one of the pioneers in electric lighting in the United States. Naturally his reminiscences of the early days of the lighting industry in this country are full of interest, and for this reason he was sought out and interviewed concerning the growth of the industry and its beginnings.

"The wonderful thing," said Mr. Hebard, "in the history of this industry is the rapidity of its growth. Its history is comprised in about 20 years and we all know what it has become to-day. In 1880 the companies engaged in electric lighting, and none of them in those days was doing more than making a few exhibition lights, were mostly named after inventors. There was the Weston Company, the Brush Company, the Fuller Company and the Thomson-Houston Company, all doing arc lighting. Incandescent lighting had hardly begun in 1880.

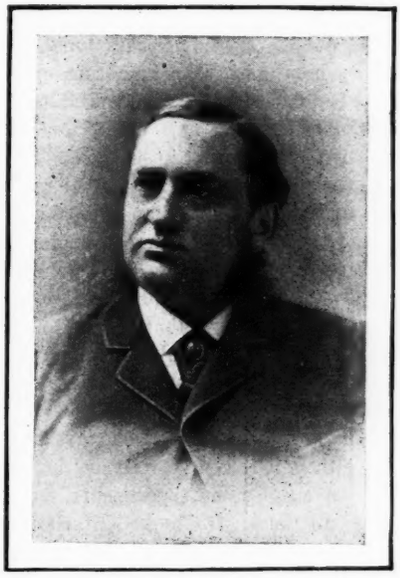
"During that year the United States Electric Lighting Company put a plant in the Equitable Building, in New York city, and distributed lights through the neighborhood. These lights were paid for by the consumers, so that, we may say, this was the first central station for incandescent lighting in New York. I remember that through the Wall street district there were quite a number of offices using incandescent lamps. The Stock Exchange, Chatham National Bank, Messrs. Hatch & Foote, Messrs. Carter & Hawley, J. H. Davis & Company, as well as several other banking and broking firms, used the incandescent light. The lamp of those days was the spherical bulb, paper-carbon filament type, known as the Maxim lamp. Those of us who remember those ancient lamps recall that their filaments were made somewhat in the shape of the letter 'M.'"

In reply to a question about the Paris Electrical Exposition, which was held at the Palais de l'Industrie in that city in 1881, Mr. Hebard said:

"There was exhibited the Edison, Lane-Fox, Swan and United States or Maxim lamps, but there was no such widespread exhibit of the incandescent light as we are familiar with to-day. Indeed I believe that none of the exhibitors illuminated a space of more than a few hundred square feet.

"I returned in November, 1881, and shortly afterward assumed the presidency of the United States Company. During October of that year the ferryboat Jersey City, of the Pennsylvania system, was equipped with a Weston generator and Maxim lamps, and shortly afterwards several other boats of the same line were similarly equipped. Most, if not all, of this apparatus is working to-day, which speaks volumes for the excellence of its construction.

"The United States Company began its work in a factory at Sixth avenue and Twenty-sixth street, in New York city, and subsequently removed to Avenue B. In the early part of 1881 it absorbed the Weston Company and occupied also its factory at Newark, N. J. For some time it furnished incandescent lights from the old Sixth avenue plant to apartments in the Cumberland Building, to Caswell, Hazard & Company's drug store, Theodore B. Starr's jewelry store and other places in the vicinity. It was about this time, or perhaps early in 1882, that the United States Company put an arc lighting plant in the New York post office. In September, 1882, the Edison station in Pearl street was opened with 2,323 lamps. This was a great achievement for that day, but how wonderfully has this business increased in the short period of 18 years that has since elapsed."



GEORGE W. HEBARD.

Referring to the Sixth avenue and Twenty-sixth street plant, Mr. Hebard said: "Of course, it was in a sense a central station, but it was not a permanent institution." Returning to the subject of the exposition at Paris, Mr. Hebard said that among the exhibits attracting much attention were the storage batteries of the Planté, Faure and Sellon-Volckmar types. "It may be remembered," said he, "that not long afterward there was an endeavor to realize some sort of community of interest by organizing the 'Gramme Electrical Company of the United States.' In this were included the United States, Weston, Brush, Edison, American (afterward called Thomson-Houston), Jablochkoff and Fuller companies. Mr. Henry W. Hoyt, of the Fuller Company; Mr. Geo. W. Stockley, of the Brush company, and Sherman D. Eaton, of the Edison company, were the active men of the organization with whom I was brought in contact at the time. Among the lawyers that were prominently identified with the business the older members of the fraternity will remember, were Leonard E. Curtis, Benjamin Thurston, Amos Brodnax and Grosvenor P. Lowry, of whom the latter three are now deceased."

Speaking of the arc lighting industry of the time, Mr. Hebard said that about 1881 the largest arc light machine supplied current for only 16 lights. "Indeed," he remarked, "any machine that consumed more than 15 horse-power was considered exceptional. When Mr. Brush made his 50-light machine it was esteemed a giant and a wonder. About the same time incandescent-light machines of 250 lights capacity were considered the maximum. Within the 18 years that have elapsed such progress has been made that generators of 5,000 horse-power are common, and it is safe to say they can be made in any size that the demands of the industry call for."

Looking back over the early competitive days, Mr. Hebard recalled with some amusement the competition over the contract for the Brooklyn Bridge lighting. The United States Company got it. "We put in Weston machines and double carbon arc lamps and the latter, I believe, are in use to-day," he said.

"I want to say in conclusion," he remarked, "that the very rapid growth of this industry in recent years has been largely induced by the introduction and development, by the Westinghouse company, during the years 1886 and 1887, of the alternating-current system which made it possible to distribute current over wide areas for all purposes, including power, as well as for lighting by both arc and incandescent lamps."

A Brief History of the X-Ray.

By Eugene W. Caldwell.

PROBABLY NO DISCOVERY or invention of the century just ended has elicited more widespread interest, or has come more quickly into general use, than the subtle and mysterious X-ray. Only a little more than five years have elapsed since Rœntgen made his famous experiments, published them to the world, and suggested for the new ray he had discovered a practical use in the field of surgery. Rœntgen, in his brilliant and classical work, has combined the patience and skill of the profound scientist with the genius of the inventor. The beautiful and useful results he has obtained were, however, but the culmination of a long series of researches which have been carried on from time to time during many years by Crookes, Hittorf, Hertz, Lenard, and other great physicists.

The study of the history of electrical discharges in rarefied air and gases leads us far back toward the beginning of the century, but it was not until 1858-1859 that Geissler made the first vacuum tubes. The tubes of Geissler were of comparatively low vacuum (about .0025 M.), and the electrical discharge through them produced a delicate glow sometimes striated and varying much in form and color with the degree of exhaustion and the composition of the rarefied gases they contained.

Professor Hittorf about 1860 discovered that the luminous stream of discharge in a Geissler tube could be deflected by a magnet—a fact which has an important bearing upon the subsequent experiments of Crookes, Hertz, Lenard, and Rœntgen.

The work of Geissler and Hittorf was followed several years later by the experiments of Crookes with discharge tubes of much higher vacua (about 0.0000001 M.). With these high vacuum tubes Crookes discovered new phenomena. He found that with sufficiently high vacuum the luminous glow within the tube disappeared. He demonstrated that within the tube there was a rectilinear radiation from the cathode which was a projection of the particles of the highly attenuated gas at exceedingly high velocity. He called this radiation cathode rays, and on account of the peculiar behavior of gas in this exceedingly rarefied state he conceived it to be as different from gas in its properties as ordinary air or gas differs from a liquid. He spoke of this highly attenuated condition as the fourth or radiant state of matter. He found that cathode rays were intercepted by metallic plates within the vacuum tube, that their impact against the glass walls of the tube produced in it a greenish phosphorescence and fluorescence and an increase in temperature. He concentrated these rays at the focus of a concave cathode and by this means was able to produce brilliant fluorescence and very high temperatures both at the walls of the tube and in various substances within it. He also noted that the cathode rays were deflected by a magnet.

In 1892 Hertz announced that the cathode rays would penetrate gold leaf and other thin sheets of metal within the tube. Soon afterward Hertz died and his experiments were continued by his assistant, Lenard, who found that many of the phenomena of the cathode rays could be observed outside of the Crookes tube. He experimented with a vacuum tube closed at the end opposite the cathode with a thin sheet of aluminum and found that the radiation which proceeded through or from the aluminum wall of the tube would pass through many substances opaque to ordinary light; after passing through such substances it would excite fluorescence in crystals of barium, platinum, cyanide, and many other salts, and that it would affect sensitive photographic plates in much the same manner as ordinary lights.

Lenard thought that all of these phenomena were due to the cathode rays alone, and, although it can scarcely be doubted that not only in his experiments, but in many of those of Crookes, Hertz and other investigators, X-rays were produced, they were not recognized and it remained for another discoverer to bring the results of these long years of patient scientific research into practical application in our daily life.

Early in November, 1895, Professor William Conrad Rœntgen, then a professor of physics at the Royal University at Würzburg, noticed that a piece of paper coated with barium-platinum-cyanide fluoresced brilliantly in the neighborhood of a Crookes tube, even when the tube was covered with cardboard which intercepted all of the ordinary light. Further investigation proved that the fluorescence was caused by a radiation which emanated from the point of impact of the cathode ray against the glass wall of the vacuum tube. It was evident that this radiation did not produce the sensation of light and that it passed readily through cardboard, which was opaque to ordinary light. Rœntgen also noted that all substances were transparent to this radiation, though in widely different degrees, varying roughly with the density of the material; that the radiation was rectilinear; that it could not be refracted or reflected to any appreciable extent, and that it was not deflected by a magnet. Hence it was obvious to him that this radiation was different from the cathode rays of Crookes, Hertz and Lenard. He continued his observations, both with the fluorescent screen and the photographic plate. Most of his early work was of a purely scientific nature and had for its object to determine, if possible, the exact nature of the new radiation, which he named X-rays, probably because of the significance of the letter X in mathematical formulæ.

Using photographic plates, wrapped in black paper to protect them from ordinary light, he obtained, with the X-ray, shadow pictures of metallic objects in a wooden box and of the bones of his hand. The great possibilities of the X-ray in surgery were noted by him, and in December, 1895, he communicated his discovery to the Physico Medical Society of Würzburg.

This communication was published immediately all over the civilized world and hundreds of investigators repeated the experiments of Rœntgen and took up at once the work of practical development of his discovery. At this time Crookes tubes and the electrical appliances necessary for operating them were delicate experimental apparatus and were rarely seen except in the laboratories of scientific investigators.

For exciting Crookes tubes an electrical discharge of rather high potential is necessary. This may be obtained either from a static machine, a Tesla or high-frequency coil, or from the ordinary induction coil. Excellent results have been obtained with all of these appliances and each has its peculiar advantages. When

Mr. Eugene Wilson Caldwell was born in Savannah, Mo., and educated at the University of Kansas, graduating with the degree of electrical engineer. In conjunction with Professor Blake he made the interesting and successful series of experiments in telephony to lightships for the Lighthouse Board of the United States Treasury Department. Becoming interested in X-ray work, he established in New York city a laboratory for the study and application of these rays in surgery and has for several years used the X-ray in diagnosis and examination for various hospitals and surgeons. He is the inventor of the liquid interrupter and a number of other electrical and X-ray auxiliary apparatus.

the static machine is used the action of the X-ray tube is very steady and is well adapted for fluoroscopic examinations. Static machines of sufficient power for X-ray work are, however, very cumbersome and more or less irregular in their action. The chief advantage of the high-frequency coil is that it is so well adapted for alternating-current source of supply.

The most practical form of exciting apparatus and the one in most general use is the ordinary induction coil. Since the discovery of the X-ray this instrument has been developed from a rather clumsy and imperfect piece of laboratory apparatus to a practical working machine for use in hospitals and physicians' offices or even to be carried into the field as part of the surgical equipment of an army.

As to the best size of coil for X-ray work there has been much diversity of opinion. At first there was a tendency toward coils giving sparks fifteen or twenty inches long, but it is now pretty well established that those giving sparks about ten inches long and of considerable energy are more satisfactory. Many of the improvements that have been made in induction-coil apparatus relate to the appliances for interrupting the primary current, and of these the liquid and electrolytic interrupters are perhaps the most novel and striking. In this class of interrupters the primary current is led through a conducting liquid and the break is effected by converting a portion of this conducting liquid into a non-conducting gas. The non-conducting gas is produced by the passage of the primary current through the liquid and may be either the product of its electrolytic action or vapor due to its thermal effect, or both.

Interrupters of this kind operate with high frequency and thus enable a large amount of energy to be taken from a coil of a given size. On account of their high frequency they produce a steady excitation of the X-ray tube—a quality very desirable for examinations with the fluorescent screen.

The interrupter of Wehnelt has an advantage peculiar to itself in that it enables the ordinary induction coil to be operated for X-ray work with an alternating-current source of supply. All of this class of interrupters, however, deteriorate with use, they are rather noisy in action and they give off disagreeable fumes.

The first X-ray tubes were of the pear-shaped type, used by Crookes about 1879. The focus tube of the type now in universal use appeared within a year after Rœntgen's preliminary announcement. In this tube the cathode is concave, and a thin plate of platinum or iridium, which is usually made the anode, is placed at the focus of the cathode rays and inclined at an angle of about 45 degrees with the axis of the tube.

The character of the X-rays delivered by an X-ray tube varies much with the degree of its vacuum, and one of the chief difficulties in operating these tubes is to maintain the vacuum at the point of greatest efficiency.

When a new tube is operated the heating of the platinum anode and the glass may drive off occluded gas and lower the vacuum to such an extent as to seriously impair its action. After long continued use the vacuum of a tube usually increases and finally becomes so high that no discharge will pass through it. Various devices for regulating the vacua of X-ray tubes have been introduced. The one most commonly used is similar to the one used by Crookes in 1879, and consists of a small auxiliary chamber connected with the tube and containing some chemical which may be made to liberate a little vapor by heating it or passing an electrical discharge through it. The chemicals usually employed for this purpose reabsorb the liberated gas when cooled and thus make it possible to raise or lower the vacuum at will. In some tubes the regulation is made automatic by arranging a spark gap so that when the vacuum becomes too high, sparks pass between the negative terminal of the exciting apparatus and an electrode sealed into the regulating chamber. These sparks liberate a little gas and lower the vacuum until the electrical discharge passes through the terminals of the tube instead of across the regulating spark gap.

It is obvious that the degree of vacuum maintained will vary with the length of the regulating spark gap, and this may be adjusted at will.

With the use of exciting apparatus of great energy the metal plate at the focus of the cathode stream in the tube may be heated to such an extent as to be seriously injured or even melted.

The newest improvements in X-ray tubes are directed toward obviating this difficulty. The result has been accomplished in several ways. Some makers furnish tubes with hollow anodes through which cooling currents of water or air may be circulated. Some of the first tubes of this type were designed by Dr. Rollins, of Boston. They are very effective, but the necessary auxiliary appliances for circulating the water or air are awkward and cumbersome. A more convenient and practical tube is one in which the anode consists of a considerable mass of a metal which has high specific heat and which, therefore, does not become hot quickly.

To facilitate the radiation of heat from the anode, it is made of a form presenting a considerable surface which is often roughened or blackened.

The best X-ray tubes are still more or less irregular in their action and require skillful manipulation in order to secure uniformly good results.

The fluorescent screens used for observing X-ray shadows are usually made of cardboard and covered with crystals of barium-platinum-cyanide—the same material that was used in the experiments of Lenard and Rœntgen. Tungstate of calcium and other fluorescent materials have been used for coating the screens, but the barium-platinum-cyanide gives by far the most satisfactory results. Almost the only improvement that has been made in the fluorescent screen of Rœntgen is the addition of a box for excluding the ordinary light. This arrangement is called a fluoroscope and is now familiar to every one.

X-ray appliances are still imperfect and more or less inefficient, but the great improvement that has been made in the last five years is apparent when we consider that at the time of Rœntgen's discovery it required an exposure of half an hour, with the old pear-shaped Crookes tube, to obtain a fair radiograph of the hand. Perfectly satisfactory radiographs of the hand are now commonly made with exposures of from five seconds to one minute, and under exceptional conditions such results have been obtained with exposures of less than a thousandth part of a second.

The most useful application of the X-ray is as an aid to medical or surgical diagnosis. In bone surgery and in locating or determining the presence of foreign substances in the body, its great usefulness is apparent. It is also of great value in ascertaining diseased conditions of the heart and lungs. As a therapeutic agent it seems to have great possibilities. It has been successfully employed in the treatment of *lupus vulgaris*, and many medical men are hopeful that by its use they may be able to cure other tubercular affections.

The X-ray has found various applications outside of the field of medicine and surgery. It has been used for detecting flows in metallic objects, for examining baggage by inspectors of customs, for ascertaining the presence of metallic particles in ores, for detecting spurious gems and for many other purposes.

No history of the X-ray can be complete without mention of the so-called X-ray burn, which has furnished the daily press so many sensational stories. Early in the development of the art it was found that prolonged exposures, especially with inefficient apparatus, would produce upon the surface of the body a more or less serious effect which appeared usually about five days after exposure to the rays, and, in its first stage resembled a sunburn. In some cases the effects were severe and painful, and lasted many months. With the increased knowledge of the subject and the improvements in X-ray apparatus the danger of producing X-ray burns has almost disappeared. In the hands of a skilled operator the X-ray can be used without the slightest risk to the subject under examination, but those who are using it a number of times every day must take some precautions to prevent the harmful effects.

What the future developments of the X-ray will be is, of course, difficult to conjecture. Great and rapid improvements in the X-ray appliances may be looked for with confidence. It seems probable that we shall never be able to refract or reflect the X-ray so as to obtain true images, and that X-ray pictures must always be shadow pictures.

It is possible that in the next century other rays more easily produced and controlled and having longer wave length will take the place of the marvelous and useful rays of Rœntgen.

The History of Power Transmission

By a Pioneer Transmission Engineer.

POWER TRANSMISSION history is the history of a scientific and engineering achievement; its origin was not in any great discovery or resulting from any great systematic invention; simply the business would demand it and the world of scientific engineers brought it forth.

When Joseph Henry rang a bell across the Princeton campus he transmitted electrical energy, but however great the importance of the work by Faraday and Henry and their fellow scientists, and however essential the work of our renowned inventors, nevertheless it is to the engineer that most of the credit is due for the present position of the industry of electrical power transmission.

It is true that some who have contributed much toward the engineering of the various plants are better known as inventors and scientists than as engineers, but still their important contributions to the art have been in the application of known principles and this, no matter how high the order of intelligence required, we call engineering. It is, unfortunately, impossible to name in the order of their importance these engineers individually, as they have worked on the problems in groups under the command of the great manufacturing companies, among whom honors are quite evenly divided.

The earliest attempts at power transmission in this country were made by the Electrical Engineering Company, of San Francisco, under the direction of Mr. N. S. Keith, employing direct-current machines with motors in series and governed by means of an automatic shunting device. While this company built machines of as high a voltage as 10,000, with currents of considerable strength, its engineering work was never carried forward with the necessary energy and skill, and eventually, in about 1893, under the combined influence of bad workmanship and internal jealousies and dissensions among the engineers of the company, an end came to what at one time promised to be a successful industry, and one which the successful work of Thury, in Italy, proves to have been based on correct principles.

The only present importance of this work lies in the fact that the plants installed in the mines and cities of California created an imperative demand for a successful system of electrical power transmission and made the owners of water-power properties ready to share in the experimental inconveniences necessary to attain the desired results. At about the time these western engineers were encountering their greatest difficulties with direct-current transmissions, eastern engineers were devoting their best energies to the development of alternating-current machinery and many were catching glimpses of the possibilities, so long neglected, in this, the earliest form of the electric current dynamically obtained. As a result of the western demand and the eastern enthusiasm orders were given the Westinghouse and General Electric companies by the Standard Consolidated Mining Company; the Telluride Company, of Colorado; Bodie Company, of California, and the Walla Walla Company, of Washington, for alternating transmission plants. Single-phase generators and synchronous motors were installed, but unfortunately without sufficient knowledge of the requirements of machine construction for satisfactory parallel operation and these plants, which to-day might be installed successfully, were found to be a constant source of expense and trouble until they were finally abandoned and replaced with two and three-phase apparatus, or relegated to the lighting business.

Thus the single-phase alternating current was laid to rest with the direct current, and by attempting the more complex before the simple, the engineers of these companies have left us without the use of two systems of transmission which might have, at the present time, their due place in the art and be an aid in the simplification of certain problems.

In 1892, however, the Westinghouse company successfully installed the first really long-distance, high-voltage plant—that at Pomona, Cal.

While this plant was operated single-phase and originally used for lighting only, it belongs to the history of power transmission in that it combines the elements of all present power plants in the use of step-up and step-down transformers, the line operating at 10,000 volts and delivering current at a distance of twenty-eight miles.

The originator of this plant, the Rev. Mr. Baldwin, of Pomona, states that the idea of its installation came to him on the occasion of a visit to Pittsfield, Mass., in attendance on a church convention. Being interested in the lights and motors of the town, he found Mr. William Stanley and with him laid out the Pomona plant. Mr. Stanley's ideas, however, seemed to his Pomona associates too radical, as he proposed two-phase transmission and a single large-sized transformer in the station and substation; in consequence the order was finally placed with the Westinghouse company, whose work was already known on the Pacific coast.

In the year following the installation of this plant the first two polyphase transmission plants were installed.

The Stanley Company put in a two-phase three-wire transmission of power and lights from a fall on the Housatonic River, about a mile above the town of the same name, to the Monument Mills in Housatonic, and thence for lighting about five miles to Great Barrington and for pumping about two miles beyond. At about the same time the General Electric Company installed, at Concord, N. H., a three-phase plant furnishing light and power to the town from a water-power about three miles distant.

These were both plants of small size and of comparatively low voltage, but success in little undertakings gives faith for greater. The General Electric Company immediately undertook to transmit 1,000 kilowatts 21 miles at 10,000 volts from the neighboring mountains to Redlands, Cal., with three-phase machinery, and the Stanley Company made the next step in advance by building a 12,000-volt machine for a 1,200-kilowatt installation at Anderson, S. C., after already having completed a large and successful plant at Quebec, Canada, while the Westinghouse company was building and installing the great 5,500-kilowatt machines for Niagara.

The successful operation of these plants brings us well into the year 1894, and after that it was business that ruled. But yet those installations that came later may perhaps give us greater praise than we ourselves are willing to claim for them. In 1893, at the Chicago congress, Lieutenant Hasson boldly stated that he knew of no successful transmission in the West. From that congress went Dr. Louis Bell to start successfully the Redlands plant, and since his success there has been no hesitation. There has been much progress and there is to-day no cessation of engineering development.

In 1894 the single step-up and step-down transformer replaced the bank of

smaller transformers in series. The revolving field machine, increasing the reliability of operation of the plant, came in 1895 and, closely following the installation of such machines at the Lachine Rapids plant, Mr. L. D. W. Magie, acting as engineer for the Royal Electric Company, installed a plant at Hamilton, Ontario, using 22,500 volts.

The following year Messrs. Scott and Mershon were experimenting with exceedingly high voltages on the plant at Telluride and obtaining results which showed that the limits were a long way beyond anything at that time attempted. As a result the Provo-Marcum 40,000-volt line was established.

Aluminum wire came next, the honor of its first successful use being divided between the Standard Electric Company, of California, and the Snoqualmie Falls Company, of Washington. Finally, as perhaps the most striking feat of the present day, Messrs. Kelly and Chesney, of the Stanley Company, are installing for the Standard Electric Company, of California, and the Bay Counties Power Company, also of California, lines exceeding 150 miles in length.

During all this history the work of Mr. L. B. Stillwell on the Niagara plant must not be forgotten, for the engineering has been of such character in that plant, which the whole world has been watching, as to give financiers confidence in the success of such undertakings. Such is long-distance transmission history as we can write it to-day. Another generation may be able to sift the good from the bad, for they will know what has endured better than we who are living in the midst of its rapid progress. A chronology made 30 years from now will forget some work that seems to us great and will exalt what to us is perhaps small, but the progress we have made is sure. The installations of the past six years are successful now, and for this honor is due to the clear-headed engineers who have brought about such a condition.

Electric Power Transmission To=day and To=morrow.

By L. B. Stillwell.

WHEN THE EDITOR of the ELECTRICAL REVIEW invited me to record a few thoughts on the subject "Electric Transmission—To-day and To-morrow," I suppose he intended to have me put aside consideration of that extremely interesting and important part of this general subject which has to do with passenger and freight transportation and limit my remarks to transmission from water-power or other sources of cheap supply, across distances altogether beyond the range of other methods of transmitting power as now developed. The first part of this subject calls for observation, the second for prophecy, but prophecy which is not mere guesswork must consider the past as well as the present, and, therefore, I may have to glance backward a little in order to look forward.

The present state of the art of electric transmission of power on the whole must be very gratifying to all who have contributed to its rapid advancement during the last decade. This advancement has been, and still is, so rapid that we are no longer able to make note, as we once did, of each new transmission plant and we no longer stop to count them. Therefore, I can not say how many transmission plants are now in operation, nor even approximately how many horse-power are transmitted. But what is to-day accomplished may be realized by reference to a few typical examples.

The plant of the Niagara Falls Power Company best illustrates what electric transmission means as regards conservation of our coal supplies. This great plant is to-day putting out power which, if produced by a steam plant so economically designed and operated as to consume but three pounds of coal per kilowatt-hour at the switchboard, would require 800 tons each day of the year, or about 300,000 tons per annum. The average consumption of coal per electrical unit output in central-station practice is at least twice three pounds, and the Niagara plant is therefore to-day doing work equivalent to that done by 600,000 tons of coal per annum, burned under conditions better than those prevailing in average central-station practice in America, and this is accomplished without robbing the future, since a water-power is simply a solar engine and its energy may be utilized without subtracting a single horse-power from that which nature intended, not only for our age, but for future ages.

Of the power developed at Niagara, about 12,000 horse-power is transmitted to Buffalo, a distance of about twenty-five miles. We speak easily of large amounts of power, but how few of us realize what is meant by the expression 12,000 horse-power. An army of 600,000 men, performing the hardest kind of physical labor, could not maintain a rate of working equivalent to 12,000 horse-power for a single day. The power which is transmitted silently and invisibly along six conductors less than one inch in diameter would easily break six steel cables of equal diameter, moving at a rate of ten miles an hour. This is accomplished by the now very moderate potential of 11,000 volts, and when this potential is doubled, as it soon will be, the power transmitted will, of course, be doubled.

On November 13, 1900, the Snoqualmie Falls Water Power Company transmitted experimentally, with entire success, nearly 1,000 horse-power a distance of 153 miles. The apparatus for a plant destined to deliver in the city of San Francisco electricity produced by a water-power 155 miles distant is now under construction. Many plants are commercially using potentials of from 10,000 to 30,000 volts and a few are using potentials between 30,000 and 40,000 volts. Apparatus as now constructed permits the use of 30,000 volts probably with no more risks of breakdown than was involved in the use of 3,000 volts in 1890. This means that in 10 years the increase in practicable potential has multiplied the range of transmission by 10 and the area of territory within range of cheap water powers by 100.

It happened that coincidently with the increase in practicable potentials, the rate

Mr. L. B. Stillwell is at present electrical director of the Rapid Transit Subway Construction Company, of New York city, and has lately been consulting engineer for the electrical equipment of the Manhattan elevated railways. Mr. Stillwell was electrical engineer and assistant manager of the Westinghouse Electric and Manufacturing Company a·d until recently electrical director of the Niagara Falls Power Company. He completed the installation of the generating and transmission plant there and has been prominently identified with the largest power-transmission work in the United States.

of interest upon capital in the United States has decreased and this also has operated to increase the range of economical transmission.

The electric apparatus required for development and transmission of power is to-day on the whole remarkably effective, efficient and durable. An efficiency exceeding 80 per cent in transmission of power over distances of 30, 40 or even 50 miles is so near the limit of theoretical perfection that I can not believe that the means employed to-day for transmitting by electricity are destined to be superseded in the near future by transmission without wires. In the case of an electric transmission utilizing a natural water-power, we approach more nearly nature's ideal in the efficiency of the means which we employ than in any other department where man endeavors to utilize the energy provided for his use, and if there be any rational means of determining whether any of our present methods in utilizing natural forces is or is not liable to be superseded, it is by reference to this ideal of nature, that is, by a determination of efficiency. If to-day we knew nothing of electric transmission by conductors and were able to transmit power electrically only by means of oscillations of the ether, we should be making every effort to invent something equivalent to a wire, that is, a practically ideal path for power.

I have mentioned what we can to-day accomplish using but 11,000 volts as compared with transmission by steel cables, but 50,000 volts is not beyond the range of apparatus as now developed, and at this potential a circuit of copper cable one inch in diameter, using a current density hardly sufficient to sensibly warm the conductor, will transmit more than 50,000 horsepower, an amount of power sufficient to load 100 steel cables of equal section traveling 10 miles an hour quite up to the limits of good practice. The loss in transmission would be less than one-fifth of one per cent per mile and the conductor would cost about $5,000 per mile.

Further improvement in the construction of dynamos, transformers, switching devices and insulators must be looked for, but we can not expect progress during the next 10 years as marked as that witnessed during the last decade of the nineteenth century. Improvements will necessarily be largely a matter of detail of construction, except perhaps as regards insulation of apparatus and conductors. While rapid and substantial progress has been made in the direction of perfecting insulation, we may anticipate considerable further progress as up to the present time we have not approached so near the ideal as in other directions and may hope for further knowledge.

When I entered the service of the Westinghouse Electric and Manufacturing Company in October, 1886, my task the first two weeks was to take charge of six transformers which supplied alternating current to a bank of about 300 16-candle-power incandescent lamps. The transformers received energy from a circuit of No. 4 wire B. & S. gauge, operating at 1,000 volts potential, the dynamo being located about two and one-quarter miles from the lamps. This, I believe, was the first practical constant-potential alternating-current transmission attempted in America and probably the first in the world. Although the power transmitted in this case—about 30 horse-power—was used only for lighting, the plant may fairly be regarded as the forerunner of the many plants now transmitting power, not only for lighting, but for a multiplicity of other purposes by alternating currents at constant potentials.

The wonderful development within a period of 15 years, evidenced by a comparison of this plant with the Niagara installation as it stands to-day, superficially considered, suggests that we may expect further remarkable developments, but according to my view, the growth of the art of electric transmission may be represented graphically by a curve like that which we use to picture the saturation of a magnetic circuit—it rises very rapidly at first but afterwards less rapidly and ultimately becomes nearly horizontal. I do not mean to say that we have arrived at the saturated part of the curve, but I do believe that we have gone so far that from now on the rate of rise must be relatively slow. I also believe that so far as power transmission is concerned we are destined to adhere to our present curve rather than to abandon it for another.

Electrical Measurement of Furnace Temperatures

By Dr. Leonard Waldo.

A PROBLEM which constantly confronts the engineer who has to do with the treatment of metals is: What are the best methods of expeditiously determining high temperatures? In metal works, where large masses of material are poured and heated to high temperatures, the element of safety to the works and men has developed a high regard for the special shop instinct and training, by which that high degree of mutual confidence and dependence is established necessary to the successful cooperation of a number of men in these difficult and dangerous operations. A scientific man entering such work for the first time is very much impressed by the difficulty of making changes in well-established methods, even when such changes are the result of a better knowledge in the regions of pure science. The art of working metals is oftentimes passed from father to son or to fellow-workman, and a shop process which is apparently without rhyme or reason will at times secure results which it requires the lapse of years to explain. The ordinary process of poling copper is a case in point; it would be a most interesting thing for some chemist to really explain with both the reason and the fact this fundamental operation.

The shop difficulties above suggested have particularly operated against accurate determinations of high temperatures. The men in control of the workmen running smelting furnaces and muffles are keenly sensitive to anything which may distract the attention of their men at critical moments. Stray wires and the flimsy scientific apparatus of the laboratory introduced around such furnaces lead to trouble; young men who have the necessary scientific qualification are apt to be in ill-repute with the class of men who distrust their so-called theoretical book-learning. It is a very rare exception, therefore, that the large works, either in copper or steel, in our country, have a prevailing knowledge of temperature in their industrial operations. So long as brass was the main alloy, or substantially the only one, shop experience and practice could be relied upon for successful results. Of late years there has come rapidly into use other white metals. Zinc and tin and a whole category of crucial high temperatures are important for the successful manufacture of the copper alloys, nickel and manganese steel, chrome, tungsten and molybdenum steel.

Professor Carl Barus, now of Brown University, was the first physicist in this country to make effective the ideas now practically available for the simple measurement of high furnace temperatures. In his classical researches, published in the bulletins of the United States Geological Survey and in various scientific journals,

Dr. Leonard Waldo was born in Cincinnati, in 1853. He has the degrees of M. A. (Yale), and Sc. D. (Harvard); is a medallist of the Royal Society of Arts (London), a member of the American Institute of Mining Engineers, American Society of Mechanical Engineers, American Institute of Electrical Engineers, and a Fellow of the American Association for the Advancement of Science. He has been a member of the faculties of both Harvard and Yale universities, and has held many important engineering positions. Most of his recent work has been in the line of metallurgy and electrolysis.

he showed that a method of great elegance and simplicity for the measurement of any temperatures up to the melting point of the refractory wires or bars used in the measurement was to be found in the direct measurement of thermoelectric currents, by a sufficiently sensitive galvanometer apparatus, set up in a thermoelectric couple consisting of any pair of dissimilar metallic wires. Barus conducted exhaustive researches in which many types of this apparatus were shown to be powerful instruments of research. In England, Roberts Austen has freely applied this idea to metallurgical processes, and, in France, H. Le Chatelier has constructed pyrometers for all sorts of high-temperature measures on this principle.

The principle, clearly stated, is this: If two wires of different material, such as gold and silver, platinum and an alloy of platinum, manganese steel and nickel steel, German silver having two different percentages of nickel, or any other two wires essentially different in metallic constitution, have one pair of ends joined together in electrical contact, and the other pair of ends—which may be at any distance from the first pair—are connected with a sufficiently sensitive galvanometer, if there is any difference between the temperature of the first pair of ends and the second pair of ends, an electric current will flow which will register its amount by a deflection of the needle or mirror of the galvanometer. Furthermore, the amount of this deflection will be proportional, within practical limits, to the difference in temperature existing between its two sets of wire-ends. There are, of course, wide differences in the availability of different wires for this purpose; wires must be chosen which will not melt or disintegrate at the temperatures of the furnaces in which the ends are to be placed; the amount of current flowing through such wires, when exposed to the furnace temperatures, must be quite within the deflection reading of the galvanometer mirror or needle; but, within these limits, the number of wires that can be used is indefinitely large, and the method of determining the scale values of the galvanometer is that of simply exposing the pair of ends away from the galvanometer to two known temperatures and making a scale from these results. For instance, if one pair of terminals joined is exposed to the temperature of boiling water, while the other pair is in melting ice, and in the melting ice the single members of the pair are connected with the terminals of the galvanometer, the displacement of the mirror or needle is the displacement produced by the number of degrees corresponding to the difference between the temperature of melting ice and the boiling point of water under those particular conditions. Of course, in a determination of this kind, the water must be pure and free from acid reaction.

We owe to the Reichsanstalt, in Berlin, the practical calibration of the best platinum and platinum-iridium couples for this purpose. These couples may be bought of the dealers in scientific metallurgical appliances and galvanometers, made with their scales corresponding to the special platinum couples sold, are sent out by Kaiser and Schmidt, in Berlin.

In the actual installation of such apparatus in works it will be found practically impossible to use any ordinary form of sensitive galvanometer. The continuous vibration of the ground from rolling machinery or steam hammers can not be overcome by any device which the writer has heard of or tried. Luckily for American practice, Mr. Weston has made millivoltmeters with jewelled bearings and aluminum needles of the deadbeat type. These millivoltmeters, if made with the left-hand limit of the scale reading zero, give a sufficient range to indicate, say 2,000 degrees Fahrenheit under a potential difference of twenty millivolts at the free terminals of the wires. Assuming the millivolt scale to be 5.4 inches long, one one-hundredth of an inch displacement of the needle corresponds to about four degrees Fahrenheit.

Pairs of wires may be chosen such that this range of 5.4 inches may be made to cover almost any number of degrees of temperature, convenient to the individual operation involved. For instance, in low temperature annealing of steel the pairs may be chosen such that 1,500 degrees are distributed over the 5.4 inches. This enables temperatures between a dull red cherry heat of the annealing furnace to be the upper limit temperature recorded and may be easily obtained by combining a high nickel-steel and manganese-bronze wire together. As a matter of practice, it is better to standardize the millivoltmeter in terms of two coils of wire from which a new supply of terminals at any time may be cut. This enables the free use of terminals without solicitude as to breakage or injury since they can be expeditiously replaced.

In work where temperature determinations are of continuous importance, and where the furnaces are distributed over considerable acreage, it is a great satisfaction to establish at a convenient point such as a central office the galvanometric apparatus with a substantial switchboard so arranged that by pulling in place any one of a number of well-made electric switches, the galvanometer is put into circuit with a thermoelectric couple in any desired furnace. This implies a complete system of wiring leading from the galvanometer room to all parts of the works where there are furnaces in place. The wiring should be of good weight, so that the potential leakage along the leads themselves shall be insignificant as compared with the resistance of the thermoelectric couple. The resistances of all the leads from the galvanometer should be small and practically uniform. A single couple is placed in each furnace under suitable protection against damage by accident. With a system of this kind, a watchman, with slight instruction, is enabled to keep a continuous record at stated hours for every furnace in the plant; and where such installations have been built probably the greatest difficulty in the way of securing uniform results of finished material has been removed.

No other method has shown itself to be comparable in facility of use and certainty of results to the one just outlined. It is often convenient, however, and for certain operations where the limits of permissible difference in temperature are wide, to have some quick optical method for determining the actual temperature to which a body has been heated above a low red heat. For this purpose, optical methods are used which are based on the fact that as a body becomes luminous from the action of heat, the red rays of the spectrum are first appreciated by the retina of the eye, and the other rays of the spectrum are gradually added as the radiating body becomes hotter, until the body is at a glowing white heat.

The degree to which the partial spectrum has been formed by increased heating of the metal under examination, will be indicated by the degree of rotation necessary to give to a polariscope analyzer when the light is passed through the quartz plate of a determined thickness. This principle has given rise to the compact and very portable optical pyrometer made by Mesure and Nouel in Paris. In this instrument the degree of rotation of the analyzing prism is indicated on a graduated circle when the image of the hot object approaches in color the transition point between the red and green. This point is quite sharp in actual practice, and an expert observer will repeat his observations within 10 degrees centigrade. With this optical pyrometer, if 26 degrees of rotation correspond to 700 degrees centigrade (1,290 Fahrenheit), 69 degrees of rotation will correspond to 1,500 centigrade (2,730 degrees Fahrenheit). In order to use this instrument, one requires considerable practice, and the conditions of lighting the furnace must be such that very little of reflected white light from other objects gets through the apparatus to vitiate the effect of the light from the heated object whose temperature is to be determined. The most satisfactory results are only obtained with this instrument by keeping oneself in constant practice. The glowing coals of an ordinary kitchen fire afford an observer who wishes to become expert with this apparatus a convenient means of practice.

There are other optical methods, notably the one proposed by Le Chatelier, which involve comparison of the light emitted from a glowing, heated body with the light from a standard candle—an added complication with which the writer has had no personal experience.

Early Experiences of a Pioneer Telephone Man.

By E. T. Gilliland.

THE INCIDENTS which are herein related, though of little consequence in themselves, may be of interest, growing out of the fact that they are the experiences of one actively engaged in the early beginning of the practical development and manufacture of electrical apparatus in this country.

In my library and among other records I have data which, if compiled, would give a history in detail of the early telephone exchange work in all the leading cities. Some day I may be able to give you this for publication.

In the Winter of 1859-60, in a small town on the western division of the Erie railway, the writer learned the art of telegraphy. The telegraph line was equipped with Bradley relays, which, by reason of their peculiar construction, as subsequent experiments have proven, made a fairly good magneto telephone. It is a curious fact that it would have been possible for the operators along the line to have heard the sound of each other's voices. The apparatus and all the necessary conditions existed, at that time, but there was no genius to discover its wonderful possibilities and thereby give us the electric telephone many years earlier.

After becoming sufficiently experienced, I obtained employment in the Western Union office in Cincinnati, and was assigned to the duty of attending repeaters upon lines over which government despatches were transmitted at night, between Washington and the armies in the south. Except in stormy weather, the repeaters required little attention, and being alone in the office all night gave me an opportunity to experiment with the instruments, batteries and other apparatus, and to study such books upon the subject of electricity as were then obtainable. I acquired the knowledge necessary to engage in the manufacture of electrical apparatus, and the small concern established was the first of its kind west of the Alleghenies. The first article of manufacture was a learner's telegraph outfit: the next, a dial telegraph for use upon private lines between offices and factories; and then followed annunciators, call bells, alarms and signal apparatus for various uses and occasionally some electrical contrivance for a special purpose, which, together with private telegraph line building, comprehended all of the electrical business for several years.

Our first business of any importance was the construction of a private telegraph line for the well-known firm of Proctor & Gamble. This line was undoubtedly the first private telegraph line built in the west. It was equipped with dial telegraph instruments, but was found so convenient and was used so much that a signal code was adopted and most of the communications were made by sound. Others soon learned the advantages of private wires and this branch of the business grew rapidly and soon required additional capital, which led to the incorporation of a company to engage in this business exclusively, and it grew to be a large and prosperous concern and was ultimately absorbed by the telephone company which owns and operates the telephone business in Cincinnati and vicinity.

Through being telegraph operators employed in the same office, I had become well acquainted with Mr. Edison, and in 1872 became associated with him, first in his factory in Newark, and afterwards in his laboratory in Menlo Park, participating in much of his early telephone work, and when the Bell telephone was brought out all of this experience was directly in line with what was needed in the development of the telephone business. Through family connections I was well acquainted with Mr. Hubbard, who controlled the Bell telephone in the beginning, and I quickly entered into a business arrangement which has practically continued to the present time.

The most serious troubles encountered in the early days of the introduction of the telephone were the difficulties in obtaining the necessary apparatus and supplies and men who were experienced in electrical work. The business grew more rapidly than the most enthusiastic had anticipated and some of the plans and calculations where large sums of money were involved were, in the light of what we now know, simply ridiculous. Switchboards that were originally intended for telegraphic purposes were used, but on account of their limited capacity were soon discarded and the various contrivances and makeshifts that were adopted for temporary use until something better could be obtained were numerous and in some instances comical. Among these were clothespins, with twisted insulated wire snapped onto binding posts for making connections, and hotel and house annunciators mounted above each other so high that the operator required a long pole to replace the annunciator drop.

The original telephone subscribers' outfit was furnished in separate parts and the connections between magneto bell, transmitter and battery were run around and tacked to the wall. This was not only troublesome and expensive, but when not skillfully done, presented a bad appearance. The Gilliland Electric Company brought out a subscribers' outfit with the magneto bell mounted upon a base board, to which was attached a battery box, the top of which was a desk, all connecting wires for transmitter, battery, etc., being secreted behind the baseboard. This was universally copied and, as everyone knows, is still used. Illustrating how valuable improvements may be made by persons not aware of their importance, a Denver grocery keeper, who is probably still ignorant of the fact, was the first to suggest this arrangement. He had his telephone outfit screwed to a board partition behind which he ran the wires, and underneath the telphone he screwed a soap box in which he placed the battery and on top of which he placed his order book for entering orders received over the telephone. His wooden partition was the baseboard and his soap box was the desk and battery box.

The Gilliland Electric Company, of Indianapolis, was fortunate in being able to secure in the early beginning of the telephone business a large factory fully equipped with suitable machinery. It turned out 100 complete magneto bells per day and a corresponding number of switchboards and other telephonic supplies. It is a source of satisfaction to be able to say that, before business interests made it desirable to consolidate, this concern had equipped the exchange in Boston, the home of the telephone, and many other of the principal cities of this country. Its magneto bell of over 20 years ago is the magneto bell of to-day without material change or improvement, and its manager was called upon to organize and conduct the mechanical department of the Bell Telephone Company, and its secretary and treasurer is now the general manager of the Western Electric Company.

The Present Status of the Electrolytic Refining Industry in the United States.

By Titus Ulke.

THE WONDERFUL development of electrolytic refining, that is, the art of purifying metals or alloys by removing the objectionable impurities and contained precious metals from the alloys or crude metals to be refined and simultaneously electro-depositing commercially pure metals, in the United States can best be appreciated by comparing the condition of this industry in previous years with its status to-day.

Let us consider in order, the electrolytic refining of bullion or alloys of copper, silver, and of gold, which are to my knowledge, the only metals or alloys electrolytically refined on a commercial scale in our country.

Copper—The art of electrolytic copper refining, invented in 1865, by James Elkington, was first practically applied in the United States in 1879. At this time small electrolytic separating works were operated at Phoenixville, Pa., with two of Weston's nickel-plating dynamos, but the Balbach establishment of Newark, N. J., was the forerunner on a large scale of this branch of metallurgy.

The progress of electric refining, from its introduction, 20 years ago, until to-day, has certainly been phenomenal. Since 1880, when by far the greater part of our copper, in the condition of sulphide or matte, was shipped abroad to be refined, there has been a steady increase in the quantity of crude copper or matte refined here and a decrease of the amount shipped for refining to Europe. Our refiners now smelt and refine practically all of our domestic matte and crude copper, and in addition, treat electrolytically a considerable quantity from other countries, among these being Mexico, Australia, Tasmania and Japan. Our copper exports, which are very considerable both in tonnage and in value, now consist of refined copper, instead of the much less valuable ore, matte or bullion as formerly, and we no longer therefore pay a tribute to foreign refiners.

A glance at the statistics of production of electrolytic copper during a few recent years, will show the rapidity of the increase.

In 1889, according to the census, the United States produced nearly 80,000 short tons of fine copper, of which less than 25,000 tons were obtained electrolytically. Only five years later, the production of electrolytic copper in the United States alone had risen to over 57,000 tons or nearly one-third of the world's copper output at that time, and it steadily increased until in 1900 it reached the enormous total of 211,000 tons or about 422,000,000 pounds. This is eight times what it was 10 years ago and equal to half of the entire copper production of the world.

The estimated daily output of the 11 copper refineries in this country is 579 tons. From the copper treated are obtained gold and silver slimes containing over 53,000 ounces of silver per diem, or over 19,400,000 ounces per annum, besides nearly 174,000 ounces of gold. It thus appears that more than one-third of our total silver output is now derived from copper ores. It is also interesting to note that the cost of refining copper today is but half of what it was 10 years ago, and that contracts have been recently closed for refining copper anodes for as low as $8 per ton. We will now consider some of the conditions which have made such a cheapening of the cost possible, and outline the present practice of electrolytic refining.

As is generally known the object of electrolytic copper refining is two-fold: First, the saving of the gold and silver always found in crude copper, and secondly, the separation and removal of the bulk of the impurities, such as antimony and arsenic, from the fine copper, so that the latter will possess a high electrical conductivity and will be suitable for drawing into wire, or pure enough for the various uses for which copper is required in the arts.

Mr. Titus Ulke was born in Washington, D. C., in 1866. In 1899 he graduated from the Royal School of Mines, at Freiberg, Saxony. After visiting various mines and metallurgical works in Europe he became chemist to the Harney Peak Tin Company, in South Dakota; later assayer for the United Smelting Company; afterward chemist of the Electrolytic Copper Refining Works, of the Anaconda Mining Company, in Montana. In 1893 he was metallurgist to the mines and mining department of the Chicago World's Fair. During the Spanish War he was Assistant Inspector of Ordnance, U. S. A., resigning this position in May, 1900, to become engineer in charge of the Copper and Nickel Smelting and Refining Works of the Lake Superior Power Company, at Sault Ste. Marie, Ont. Mr. Ulke is a recognized authority in electrometallurgical work and has written many papers of importance upon this subject.

There are at the present time only two systems of refining in commercial use—the multiple and the series system. The series or Hayden system is in use at only two refineries, one at Baltimore and the other at Brooklyn, and is only advantageously employed where the crude copper to be refined is of uniform high grade and can be rolled out into smooth long sheets about one-quarter inch thick.

In the usual or multiple system the anode sheets are cast into plates and not rolled, and they are usually between one and two and one-half inches thick.

As the series system requires a rolling mill, which will consume about one-third of the power of the plant, and a special refining of the crude blister copper to adapt it to rolling, it is not in general use in the United States.

The composition of typical anodes of refined blister copper is as follows: 99.250 per cent copper, 0.338 per cent silver, 0.001 gold, 0.300 per cent oxygen, 0.054 per cent antimony, 0.033 per cent arsenic, 0.009 per cent lead, 0.008 per cent selenium and tellurium, 0.002 per cent bismuth, 0.002 per cent nickel and a trace of iron.

After being electrolytically refined and melted into wirebars and other shapes for rolling and conductivity purposes, the commercially pure electro-deposited copper obtained from such anodes has approximately the following composition: 99.925 per cent copper, 0.001 per cent silver, 0.070 per cent oxygen, 0.002 per cent antimony, 0.001 per cent arsenic and 0.001 per cent lead.

The chief characteristic of modern copper refining in the United States is the introduction and adoption of efficient labor-saving devices, both to and from the melting furnaces and the electrolytic tanks. Thus the largest and probably the best equipped electrolytic refinery in the world, *i. e.*, the Raritan works of the Lewisohn Brothers, at Perth Amboy, N. J., is provided with a simple and very effective casting arrangement, in which the molten copper is tapped from the melting furnaces into moulds attached to an endless conveyor, running in front of the furnace, but sunk below the floor level and covered by removable iron plates, so as not to interfere with the approaches to the furnace in anyway.

(To be concluded)

Notes on Electric Heating.

By James I. Ayer.

IN ALL PROBLEMS of generating and utilizing electricity the production of heat has to be considered, as an electric current can not be generated or caused to flow without some of the energy applied being converted into heat. Inasmuch as the advanced workers in the electrical field were employed in carrying to a higher state of development the established industries that sorely needed their services and furnished ample food for the most ambitious—because of such pressing demand for all who had ability, the early production of electric heating apparatus was left in the hands of those less informed.

At the World's Fair, in 1893, creditable exhibits were made of the possibilities of this branch of development that, to the casual observer, indicated a flourishing development in a variety of directions of the application of electric heating.

The early electric heating apparatus having defects which it took time and experience to correct, was purchased by or sold through dealers and contractors who knew little or nothing about the apparatus, but in the public eye were considered as experts, and when trouble came they would attempt to correct it, make a bad matter worse, and with very limited experience condemn the apparatus as a whole.

A period of seven or eight years of such experience by the public with struggling manufacturers gave electric heating apparatus an unenviable reputation among those engaged in the general electric work, building up a wall of prejudice which was inevitable. This experience was not only common to America, but to Europe as well, and while for a time the results were the same, *i. e.*, practical failure, I believe that it can be claimed with justice that at all times the best product of the United States has been far superior to that of Europe, and for the past three years our export business, though small, has been constantly increasing, while foreign electric heating goods have never been in the American market.

In the earlier products practically all the miscellaneous heating devices were made with heaters of German silver wire or high-resistance steel alloy, wound in a variety of forms of coils, generally insulated with asbestos or mica from the surrounding mass that was to be heated and between the layers of the coils.

A little later the process of enameling on iron, and embedding the wires in enamel, came into vogue. This latter method was a decided step in advance, but owing to the lack of experience, lack of knowledge of the production of enamels and the fact that they were confined to the use of German silver almost entirely for the resistance which constituted the heating element, the apparatus was more or less delicate. For many years no improvement whatever was made in the enamel, and so far as we are informed the conditions in that particular that existed in Europe in the earliest applications are the same to-day. In this country we have done better. The enamel industry for electrical work has made rapid strides in the past three or four years, so that it is now a high-class insulation as against a very indifferent one as it formerly existed. Equally important improvements have been made in the character of resistance metals used.

For a great variety of application the enamel method seems ideal, for it permits the heating element to be firmly attached to any surface area it is desired to heat that may be made of cast iron, or steel, distributed over that surface with perfect uniformity, so that every portion of the resistance has practically the same relation to the surface to be heated, thus producing perfect uniformity under working conditions.

Enamel, instead of being as brittle as glass and as easily fractured by sudden heating or an accidental blow, is now made so tough that it may be struck rapidly with a hammer without perceptible injury.

Electric cooking apparatus is fast becoming a factor in competition. For upwards of three years the large restaurant at the General Electric Company's works at Schenectady has had a kitchen operated exclusively by electricity, and they can serve anything, from a chop to a boiled ham.

Numerous office buildings throughout the country are provided with similar kitchens, and in many homes auxiliary equipments are in operation which have displaced the familiar gas range.

The thorough practicability of electric kitchen equipments for modern apartment houses has been demonstrated in a most emphatic manner. Thirty kitchen equipments were put in an apartment house at Utica, N. Y., in March, 1900. After six months of practical experience 70 additional sets of apartments were equipped by the same purchasers (making 100 in all), and gas ranges previously used in 50 of the apartments were discarded to make way for the new method. In these apartment houses the hot water for the bath and sink is supplied from a central plant, and the building is heated by steam, but for all other heat requirements in the kitchen no other provision is made except electrical.

This step in the establishment of electric cooking apparatus is the broadest that has been made, and the facts recited above tell the story in all its elements as fully as a repetition of the expression of the various parties interested could possibly do.

In another field the electric smoothing iron has made a wide progress as well as in the household. Several hundred laundry equipments in public institutions, as well as a large number of installations in clothing and similar factories, consisting of from 20 to 100 smoothing irons in each, stand as evidence of the progress that has been made within the past three years in the United States. Several large hat factories, varnish works, candy factories, brush manufactories, piano factories, carriage lamp factories, have complete equipments of electric heating apparatus for their special needs, generally having displaced gas.

In many communities where current is generated by water-power, large numbers of electric radiators are used in place of stoves and furnaces. Not a few factories are heated in this manner.

Over $20,000 worth of American electric heating apparatus is in operation on transatlantic liners, and constant additions are being made to their equipments.

The heating of electric street cars by this method is well nigh universal.

Several large hospitals have complete equipments for cooking, laundry work, sterilizers, and the like, using electric heat for nearly everything except heating the buildings and general hot water supply.

With dentists, electric muffles for fusing enamels, electric hot-air blasts, and other heating devices are largely in use.

The variety of applications for particular purposes in manufacturing and other directions constitute a long list, from heating a baby incubator up to the heating of large quantities of sand for a sand blast.

The demand for electric heating goods for special work is daily multiplying, and a recent single order for a particular application of electric heat requiring several thousand heaters, amounting to many thousand dollars, adds further testimony to the statement that to-day electric heating has "found" itself as a permanent industry, has reached a point where its struggle for existence is over, and it may confidently be claimed it will occupy an important place in the record when the history is written of the Electrical Century.

Mr. James I. Ayer has been identified with electrical engineering in the United States for many years. Born in Medford, Mass., he was educated in Elizabeth, N. J., and entered the profession of civil engineering. He became general agent of the Jenney Electric Company in 1885 and in 1889 was engaged to build the Municipal Electric Lighting and Power Company's plant in St. Louis, then the largest arc light station in the world. He is a member of the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, and is a former president of the National Electric Light Association. Lately Mr. Ayer has become general manager for the Heating Department of the Simplex Electrical Company, of Cambridgeport, Mass.

AN IMPORTANT TELEPHONE INVENTION APPRECIATED.

DR. PUPIN'S PATENTS COVERING THE ART OF OCEAN TELEPHONY SOLD TO THE BELL COMPANY FOR A LARGE SUM.

The closing year of the nineteenth century gave to the world an invention that, in the minds of those most capable of judging, solved the problem of ocean telephony and permits the spoken word to be transmitted over land telephone lines of any length. It is the invention of Dr. M. I. Pupin, of Columbia College, New York, whose portrait is presented on this page.

Dr. Pupin concluded, last week, negotiations with the American Telephone and Telegraph Company (Bell interests) which resulted in the sale of his invention to that corporation. The figure paid, it is stated on reliable authority, was the neat sum of $200,000 cash and in addition a salary of $7,500 per annum during the 17 years of the life of the patent is to be paid to Dr. Pupin. The ELECTRICAL REVIEW extends its congratulations to Dr. Pupin and also to the American Telephone and Telegraph Company, which promptly realized the value and importance of this remarkable and brilliant invention.

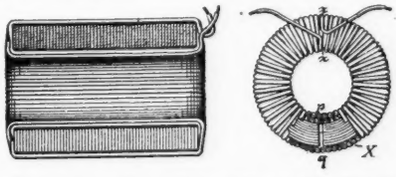
The discovery made by Dr. M. I. Pupin, and worked out in the invention described in his patents Nos. 652,230 and 652,231, of June 19, 1900, is one of the most exceptional that has been made in the electrical field in recent years. In brief, the discovery was that the retarding elements in an electrical circuit through which electrical waves are passed might be balanced out, as had been dimly foreshadowed in the work of Oliver Heaviside, by means of inductance and capacity distributed through the circuit in a particular way. The essential feature of the invention, following the elaborate mathematical analysis of the subject by Dr. Pupin, consists of the application of inductance and capacity to such a circuit in a way that is, to all intents and purposes, equivalent to a continuous distribution of these qualities, but which is, at the same time, practically possible and commercial.

The three functions of any circuit necessary to be considered in dealing with the transmission of electric waves over it are its resistance, its capacity and its inductance. When the length of the circuit is considerably greater than the wave length of the electric waves impressed upon it, in telephony or signaling, for example, then the phenomena observed and to be considered are essentially cases of wave transmission.

The modern view of electrical action enables us to understand that when electrical waves are sent over a conducting circuit most of the phenomena attending their progress take place, not in the conductor itself, but in the medium through which it passes. There is a continuous series of reactions due to the storage of electrical energy in the surrounding medium either in the form of electromag-

DR. MICHAEL IDVORSKY PUPIN.

netic or electrostatic stresses in the ether. A careful consideration of the phenomena as they appear in practice and of their laws as laid down in the elaborate mathematical investigations of Heaviside, show that electric waves in passing over conducting circuits suffer a continual attenuation, due for the most part to the resistance of the circuit itself. Inasmuch as practically all waves that are used in the



SECTION OF COIL PROPOSED BY DR. PUPIN FOR TRANSATLANTIC TELEPHONY.

transmission of signals, or of sounds through the telephone, are of a highly complex character, containing many elements of different wave-length and frequency, and since the attenuation suffered by any wave is directly dependent upon its frequency and wave-length, it happens that in ordinary circuits waves are not only attenuated and dampened in the amplitude of their vibration, but are also distorted by the more rapid suppression of their high-frequency elements and thus so transformed in character that, particularly in the case of telephonic work, they remain no longer recognizable as the original waves impressed upon the sending end of the circuit. Now it has been demonstrated analytically, by Mr. Heaviside, that if certain components of induction and capacity could be added to a given circuit so that the three elements mentioned above bear a definite relation, and if these added components are distributed in the same way that the natural resistance of a circuit is distributed throughout its length, that waves will pass over it without distortion. This "distortionless circuit" has been in some measure an ideal at which many electricians have striven to arrive ever since the announcement of its apparent possibility. Introducing capacity or inductance, however, at distinct points in the circuit was found to produce reflections of the waves sent over it and it was believed for a long time that it was impossible so to modify existing circuits as to make them approach the ideal perfection of distortionless conductors.

Dr. Pupin's investigation, begun by considering the remarkable physical analogy between the case of a vibrating string and that of an electrical conductor transmitting waves, led him to conclude that a formula might be arrived at expressing the dimensions of inductance coils and condensers necessary to add to a given circuit in order to produce an effect sufficiently close to the ideal distortionless circuit for practicable purposes. Without attempting here to go into the mathematics of the subject, it may be said that he discovered that it is unnecessary, practically speaking, to distribute absolutely these additional elements, but that a certain definite relation between the wave length of the highest-frequency impressed element of the electrical waves used and the distance apart and dimensions of the added inductances and capacities could be worked out, and that it is possible to apply the formulæ deduced in actual practice with a considerable approach to ideal perfection.

Experimenting with artificial conductors he discovered that it was possible to telephone over vastly greater lengths of cable of high capacity than had ever been possible before and that, so far as land-line telephone or rapid telegraphy is concerned, he was able so to improve existing conditions as to make any reasonable or desired length of telephonic circuit easily possible. Indeed, in the paper read before the American Institute of Electrical Engineers, at Philadelphia, May 18, 1900, he showed a design for inductance coils to be introduced at appropriate intervals in the length of a transatlantic cable, which, he demonstrated, would allow telephonic conversation to be held across the Atlantic Ocean.

It is believed by those who have investigated the subject fully that the improvement which his inventions contemplate will enable telephony over land lines of any length that are in use to-day, and will solve the difficult and attractive problem of oceanic telephony.

The Weber Rail Joint.

Opinions differ greatly in regard to questions of track work and maintenance of way, due not only to personal views but also the different existing conditions of roadbed and traffic. Most managers of electric railway systems realize that good track is absolutely necessarv and any judicious additional expenditure is advisable in order to secure a final reduction in the cost of maintenance. Especially is this true in regard to the rail fastening.

The Weber joint so holds the rail that the point of contact between the wheel and the rail at the immediate rail ends is one plane surface, and it has the necessary strength to maintain these conditions, being, in its present improved form, theoretically as well as practically constructed. Not only is this fact demonstrated by the decreased wear and tear on the rolling stock and rails, but also is shown in the extension of life to the bonding, due to the fact that the rail ends are so held that little, if any, pumping action takes place, and therefore the tendency of the bonds to break and give way is very considerably reduced. The return circuit of the rail at the joint is so maintained that power can be economically furnished long distances from the powerhouse without excessive cost for power or wire; in fact, the conductivity of the completed joint is practically equal to that of the rail. In ordinary angle bar construction it is a well-known fact that a good bond will carry current with a reasonable drop, but this loss rapidly increases with time and is soon very great on account of the disintegration of the bonding, occasioned by the fact that the joint's structure is not adequate for the load and speed which it is expected to stand, and the joint soon begins to "work," throwing an unnatural strain on the bond wires. This is forcibly and more rapidly illustrated where track is laid on soft roadbed or where there is trouble with the drainage and low joints exist.

One of the distinguishing features of the Weber joint is the angle sole plate which furnishes a rigid and substantial support for the rail ends by holding the base of the rail in such a manner that the bearing and wearing area of the rail heads are of an even surface, thereby prolonging the life of the rail by preventing depressed and battered rail ends. This is augmented by the channel, which not only gives more additional strength to the joint but acts as a protection for the wood filler which performs the function of a cushion and a packing, giving the necessary elasticity to the joint, keeping the bolts tight and furnishing a noiseless and easy-riding track so essential in street railway construction.

The only fit required in the manufacture of the Weber joint is that of the ordinary angle bar, *i. e.*, two fits which are *all* the lasting fits that can be guaranteed on rolled sections. This is illustrated conclusively by the fact that the Weber joint has an enviable record in restoring badly surface bent rail to its normal surface and alignment, extending the life of the rail, it is claimed, at least 50 per cent, and at the same time giving a smooth-riding track and reducing the cost of maintaining track, bonds and equipment. This device is manufactured by the Weber Rail Joint Manufacturing Company, of New York city.

The Babcock & Wilcox Company's New Plant.

With the beginning of the new century work was started in the new boiler works of the Babcock & Wilcox Company, at Bayonne, N. J. The engine was started at midnight, at the dawn of the new year, in the presence of the Mayor of Bayonne and a number of the city officials, and the officers and heads of departments of the Babcock & Wilcox Company.

Operatives went to work at once in the drum shop—which is the first department to be put in operation—and, in the presence of the guests, a steam drum was completed out of the flat sheets. Those present witnessed all the operations of shearing, punching, rolling, riveting and assembling involved in its manufacture. Supper was served to the guests and toasts were drunk to the success of the new plant.

The new works of the Babcock & Wilcox Company are located in Bayonne, where the company has purchased 30 acres of land having a frontage of 650 feet on the Kill von Kull, with a depth of water 25 feet on the pier line.

The plant is the largest of its kind in the world. The buildings completed have a floor area of about 160,000 square feet, to which will be added at once buildings of approximately 40,000 square feet floor area.

The plant is equipped throughout with special tools and has been designed with the greatest care to expedite the processes of manufacture by reducing to the last degree the needless handling of material and by the use of the most approved appliances.

The business of the Babcock & Wilcox Company is over 30 years established, beginning with the partnership existing between Babcock & Wilcox in the manufacture of engines in the early '60's. The first boilers were built by them in 1867. The partnership was changed in 1881 to the present corporation.

The works of the company have hitherto been located on grounds leased from the Singer Manufacturing Company, in Elizabethport, N. J., but the enormous growth of the business in later years made necessary an increase in productive capacity and, in 1899, the company decided to build the new works now nearing completion.

An Acknowledgment.

The portraits of Sir Humphrey Davy, Maxwell and William Wallace appearing in this issue are reproduced by the courtesy of the owner, from photographs and engravings in Mr. W. J. Hammer's superb collection of portraits of electricians. This collection of more than 1,000 autograph portraits is probably the most complete of its kind in the world.

Third-Rail System in the B. & O. Tunnel.

A preliminary and private test of a third-rail system recently installed in the Camden yards and the tunnel of the Baltimore & Ohio Railroad, at Baltimore, was held on January 5. The installation is made at the inventor's risk and expense. It is announced that a public test will be held on January 18.

Lighting Interests in New England Consolidated.

At a meeting of the stockholders of the Boston Electric Light Company, held in Boston, Mass., on January 7, it was voted to lease the property of the company to J. P. Morgan & Company, who, it is understood, are acting for a syndicate, for a term of not more than 99 years, at an annual rental of 10 per cent.

A Beginning of New History in Electric Traction.

One of the most interesting installations for electric traction now in operation, and one that deserves special mention in any contribution to the historical literature of the subject, is that of the Albany & Hudson Railway and Power Company. The lines of this company, extending over about 35 miles of rolling country between the cities of Albany and Hudson, N. Y., are operated entirely by electricity from a third-rail conducting system. Passenger and freight cars of standard pattern are handled with high efficiency and satisfaction on a schedule similar to that of a steam railroad. Indeed, in all respects save motive power, the Albany & Hudson road is exactly like the standard railway in this country.

Its installation in the last year of the old century marks a point of departure, and the equipment is certainly destined to become historical as the first example of electrical operation of a regular main-line railway.

Wall Street and the Electrical Stock Market.

The transactions on the New York Stock Exchange on Friday of this week were the largest ever reported in the history of the exchange. The total sales were probably upward of 2,000,000 shares. The reported sales were somewhat less than this figure, but the fact must be taken into account that some time ago the authorities discontinued the printing on the tape of transactions smaller than 100 shares, and on Friday the business in small lots must have been very large. The course of prices on Friday made it very plain that the reaction in prices on Thursday was agreeable to the substantial interests in the market, and it is even possible that they helped to bring it about. On Saturday the transactions on the New York exchange were the largest for any short day in the history of the market. The week just ended has been remarkable for the volume of business and the prices attained.

On the New York Stock Exchange, General Electric closed the week at 185 bid and 187 asked, showing a loss of 6 points. Metropolitan Street Railway, of New York, closed at 165½ bid and 166 asked, indicating a loss of 5⅜ points for the week. Brooklyn Rapid Transit closed at 82⅞ bid and 83 asked, showing a loss of 3 points. Third Avenue Railroad closed at 118 bid and 118½ asked, showing no change in the bid price and a loss of 1½ points in the asked price. Manhattan Railway, of New York, closed at 112¾ bid and 112¼ asked, indicating a loss of 2⅛ points for the week.

The following chart shows the high, low and closing prices of electrical stocks on the New York market during the year 1900:

	High.	Low.	Closing.
General Electric.....	200	120	192¼
Third Avenue Railroad...	135⅛	45¼	118
Brooklyn Rapid Transit...	88⅞	47⅛	86⅝
Metropolitan Street Rwy..	182	145¾	171¾
Manhattan Railway.....	117	84	115¼

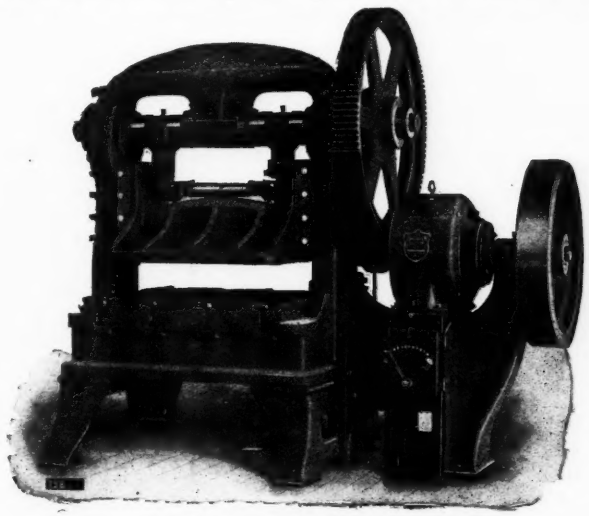
On the Boston exchange, American Telephone and Telegraph closed at 154 bid and 156 asked, showing a loss of ½ point. Erie Telephone closed at 84½ bid and 85 asked, indicating a loss of 4½ points. New England Telephone closed at 128 bid and 130 asked.

The Erie Telegraph and Telephone Company furnished somewhat of a sensation in financial circles of Boston on Friday. Through the wording of a circular calling for a special meeting some unnecessary fears seem to have been aroused, and the stock fell off some 14 points but afterwards recovered, closing at 90. It is understood that a syndicate of Boston and New York bankers have agreed to buy $7,500,000 of Erie five per cent notes to run for one year. In speaking of this question the Boston *Herald*, of January 5, says that the control of the stock of the Erie company has passed from the Telephone, Telegraph and Cable Company, and is to be put in the hands of trustees constituting a voting trust. It is understood the controlling interest is friendly to the American Telephone and Telegraph Company which now owns the American Bell Company. The new deal has brought about a closer alliance between the Erie interests and the Bell interests. The voting trustees of the Erie Telephone Company are T. Jefferson Coolidge, Jr., Chas. E. Cotting, and Geo. P. Gardner.

On the Philadelphia exchange, Electric Storage Battery was not quoted. Electric Company of America closed the week at 9¼ bid and 9½ asked, indicating a loss of ½ point. Union Traction closed at 35½ bid and 35¾ asked, showing a loss of ⅝ point for the week.

On the curb, or outside market, in New York, Electric Vehicle closed the week at 18 bid and 19 asked, indicating a loss of 2 points. Electric Boat closed at 28½ bid and 29½ asked, showing no change in either the bid or the asked price. Consolidated Equipment closed at 13 bid and 13½ asked, showing a loss of ½ point for the week.

Wall street, January 5.



An Electrical Blanking Press.

PERSONAL.

Mr. T. W. Sprague, who is associated in engineering work with Mr. Charles H. Davis, of New York and Boston, is about to start on a professional trip to California, Arizona and Texas.

Mr. Charles P. Geddes, for many years connected with the Sprague Electric Company, has entered the firm of Smith, Gray & Company, a clothing firm of New York and Brooklyn. Mr. Geddes will take with him the best wishes of a large number of electrical friends.

Mr. Horace F. Parshall, an American electrical engineer who has been located in London for several years, arrived in New York on Sunday last. Mr. Parshall visits the United States in the interests of Mr. Charles T. Yerkes and while here will place numerous contracts for machinery and supplies for the latter's new underground railway in London.

Mr. Roger W. Conant, who was connected with the Boston Elevated Railway for nine years as electrical engineer, has resigned to accept a position with the Gold Car Heating Company as manager of its New York office. Mr. Conant is well and favorably known to railway officials both here and abroad through his writings on subjects pertaining to electrical and mechanical engineering. He is a graduate of the Massachusetts Institute of Technology and has been engaged in practical railway engineering for many years. His resignation from the Boston Elevated Railway was received with regret, the management expressing their appreciation of his work and sincerely wishing him success in his new undertaking.

An Electrically Driven Blanking Press.

The accompanying illustration represents a Toledo punch, or blanking press, driven by a Bullock electric motor, which is directly coupled to the press and stands on what is practically the same base. It will be seen from the illustration that the motor requires no more space than would the driving pulley of a belt-driven machine. The motor is series wound and runs at 240 revolutions per minute, developing at that speed four horse-power. The main switch, fuse box and rheostat, as the illustration shows, are mounted upon a board fastened to the motor support. Since the machine is entirely self-contained it may be set anywhere on the floor of a shop without regard to line shafting, or may be picked up by a crane overhead and set in another position in a few minutes without delay or inconvenience of any kind.

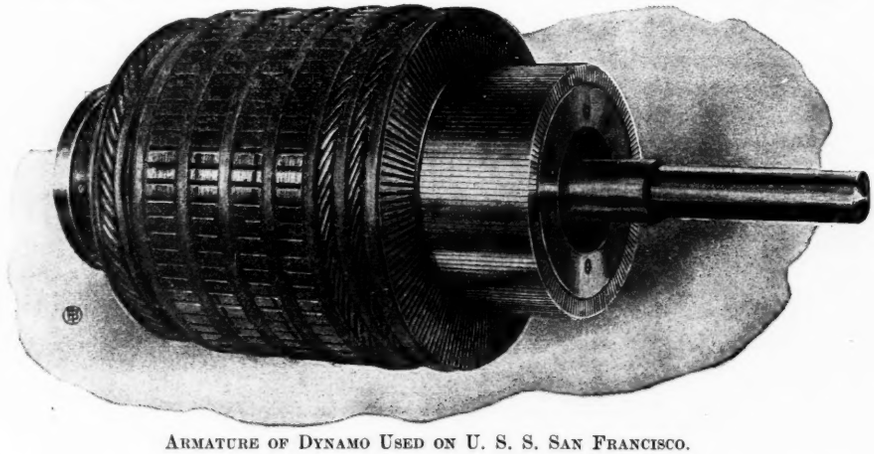
New Electrical Equipment of the U. S. Cruiser San Francisco.

The United States cruiser San Francisco, which has been refitted at the Norfolk Navy Yard, will soon be ready for active service, having been entirely modernized. Her electrical equipment has been considerably increased and consists now of four Thresher marine generating sets, of 24 kilowatts capacity each. The peculiar conditions met with in marine service and the limitations with regard to space and weight necessarily make the requirements in the specifications for navy units most severe. The field of each unit is cast steel, the pole-pieces being made separate to facilitate the removal of field coils without disturbing the balance of the machine. These field coils are wound in metallic shells and are insulated in the most approved manner with moisture-excluding material, the series and shunt windings being entirely separate, so that in case of accident to either the damaged part can be repaired without disturbing in any way the other winding.

The armature is built upon a ventilated spider of thoroughly annealed laminæ of a very high grade of material. The armature heads are extended to support the windings, the rear head being provided with a flange to protect them from injury by oil or abrasion, while the armature coils are formed of one continuous copper bar, without joints, and are thoroughly insulated before being placed upon the armature core. The slots in the core are insulated with mica boxes. This method of armature winding brings the armature resistance to the lowest possible point, by reducing the length of the circuits and removing soldered joints, there being but one joint in each armature circuit, and that where the winding is soldered into the commutator leads, which is at a point easily accessible for inspection and repair. Ventilating spaces are left in the body of the armature core, so that it is thoroughly ventilated both laterally and radially, keeping the temperature down to a very low limit.

The commutator is built upon a separate bush, so as to be easily removed and replaced by a new one in case it is desired. The bars are of hard Lake Superior copper, drawn through a die, and insulated from each other with the best mica. The commutator leads, which receive the armature winding, are riveted to the end of the bar, and the end flanges are so designed as to hold the bars rigidly in place, making it impossible for the bars to become loose or get out of alignment, thus insuring a very smooth running commutator. The illustration of the armature gives an idea of its appearance when completed.

The brush holders and method of attachment are of the greatest simplicity. In order to give free access to all parts of the machine the supporting arm is carried upon the outboard bearing. The brush holders are of the pocket type, the brushes being radially fed. The pressure is given by a finger, actuated by an adjustable spring, so as to maintain a constant and even pressure upon the commutator. This spring is insulated from the finger so that the current will not pass through it, but through the flexible conductors with which each brush is connected to the pocket, while the brushes are of such size as to give a contact surface on the commutator of one square inch for every 25 amperes of current carried at full load.



Armature of Dynamo Used on U. S. S. San Francisco.

Upon the same bed plate is mounted the engine, which is a Shepherd vertical cross compound, combining with simplicity, symmetry of form and rigidity and strength. It is compact and easy of access, the housings being entirely enclosed, so as to avoid throwing of oil, which is fed to the different bearings under pressure from a reservoir above. The wearing surfaces are provided with the most accurate adjustment for taking up friction, but the methods and principles adopted are of a simple character and readily understood. The bed and frames are of cast iron, well ribbed and braced, containing within themselves the cross-head guides, main bearings and valve gear support; the back frame contains the guides and rocker-arm bracket and supports the cylinder when the front frame is removed to take out the crank shaft, should it be desired to do so. The main bearings are provided with removable babbitt-lined cast-iron shells which are easily removed and renewed when worn, and all wearing surfaces are of very liberal dimensions. The flat balance valve is double ported, insuring a practically instantaneous admission and release of steam. Finished on both sides, it works between its seat and a heavy pressure plate, which latter is held in proper position by parallel strips cast in the steam chest and finished to an exact distance from the valve seat. Regulation is accomplished by means of the well-known Shepherd governor. The cylinder barrels with their top and bottom heads are jacketed to prevent radiation and the consumption of dry steam per hour per horse-power, when engines are carrying their rated load, averages between 21 and 22 pounds. Means are provided for ready access to all of the working parts, both front and rear frames being provided with doors through which the connecting rods, cross-heads, etc., may be adjusted or removed, while, if it is desired to remove the shaft, the front frame may be removed in a few minutes without disturbing the cylinder.

Very exhaustive tests were made on these units and excellent results obtained. The temperature requirements of 60 degrees for armature and fields, and 72 for the commutator, were easily met. The overload of 33 per cent was carried with ease, an overload as great as 66 per cent being carried for short periods, which was thrown on and off repeatedly without requiring the shifting of brushes and without the least sparking at the commutator. Under these severe changes of load the engine performance was very remarkable, the engine varying but a fraction of one per cent under these abnormal conditions. The combined efficiency of the units was found to be 86 per cent, a result that had never yet been attained in units of like capacity. The results obtained in these combined units place them high in marine and such other service as requires the highest efficiency, close regulation, and simplicity and durability in all parts. All the electrical machinery is from the plant of the Thresher Electric Company, of Dayton, Ohio.

Some New Telephone Apparatus.

Among several new features which are being prepared for the Spring trade by the North Electric Company, of Cleveland, are three instruments herewith illustrated. One of the most important of these instruments is the "Type E" wall set, which is claimed by the manufacturers to be the smallest, neatest and most compact magneto-call wall instrument, complete in all its details, ready for service, that is at present offered. This instrument is complete with batteries, and has all the features offered in the several other styles of wall instruments made by the same company. This instrument is furnished in 80-ohm series, 500-ohm bridging exchange, and 1,000, 1,600, 2,000, 2,500 and 3,500-ohm bridging instruments. This company also furnishes the same type of instrument with its new four-bar bridging generator. This it claims to be equal to any five-bar generator manufactured in this country. This instrument is exceedingly simple, being equipped with concealed-cord transmitter arm, mica-insulated long-lever self-contained switch hook, adjustable and locked receiver, pivoted ringer and with the circuits so arranged that the instrument wiring can be instantly changed from series to bridging, or *vice versa,* at the will of the installer. The company reports an exceedingly enthusiastic reception for this little instrument on the part of those managers who believe that it is well to consider not only the efficiency, but the neatness and general appearance of the apparatus furnished to their patrons, especially for use in residences. This instrument is claimed by the manufacturers to be the equal of, and in some respects superior to, any of its wall types of apparatus.

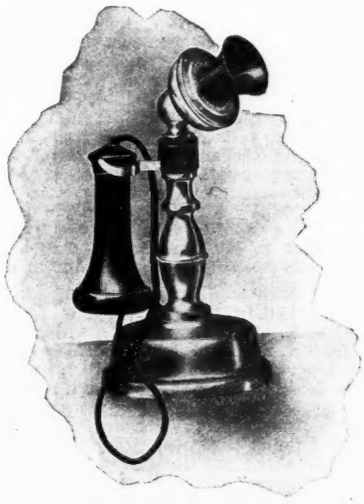


FIG. 1—TELEPHONE DESK SET.

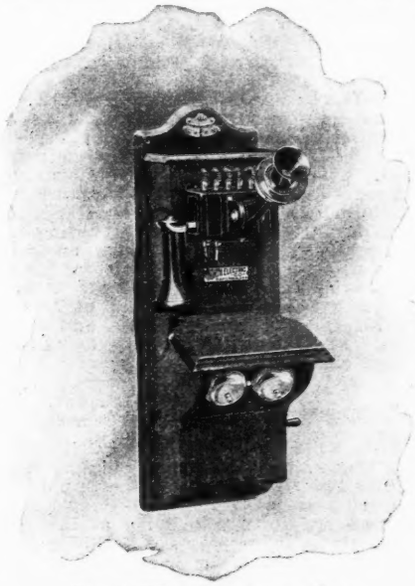


FIG. 2—WALL TELEPHONE SET.

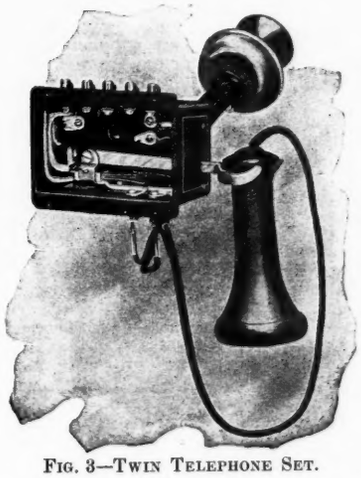


FIG. 3—TWIN TELEPHONE SET.

FIG. 4—BOTTOM VIEW OF DESK SET.

The desk set shown is one of two new desk instruments being put on the market by this enterprising company. Among the leading features of this desk set is accessibility to all the working parts without having to dismantle them in any way for the purpose of adjustment or inspection. The mica-insulated hook is on the same principle as that used in the wall sets, and has concealed conductors. This instrument is exceedingly light and well weighted to bring the centre of gravity low, so that the instrument is not liable to fall over easily, and has, as will be seen in the bottom view, the induction coil and switching apparatus to go with all terminals concealed in the base.

Another point of advantage in this desk set is the fact that the transmitter can be removed from the standard without the necessity of unsoldering or disconnecting any of the connections. The connections fall automatically into place on screwing the transmitter into its proper support.

The other new type of desk set which is being brought out by this company will differ from the one herewith illustrated and described in that the induction coil will be mounted on the terminal plate entirely independent of the desk set itself. The desk set illustrated is fully nickel-plated, and extremely handsome in design and appearance. It is just small enough and not too small.

The twin set shown herewith is claimed to be more accessible in its parts and of higher grade of workmanship and material than that offered in other telephone equipments. It is an exceedingly handy piece of apparatus for use in connection with the remodeling of old telephones, as well as with central battery telephone systems. The twin set is equipped with a long-lever switch hook with mica insulation, has an induction coil so placed that it can be removed without in any way interfering with the hook, while all circuits and contacts are easily accessible, either for repairs or inspection. The arm is hollow, the transmitter being connected with the coil by double conductors, no dependence whatever being placed upon the conductivity of the arm or joint. The joints of this twin set are milled so that all parts are interchangeable on a base.

New York Electrical Society.

The 211th meeting of the society, through the courtesy of the New York Gas and Electric Light, Heat and Power Company, will be held at the Edison station, corner of Elm and Duane streets, on Wednesday, January 16, at 8 P. M. Dr. Louis Bell, who is chairman of the National Electric Light Association Committee on Incandescent Lamp Standards, will deliver a lecture on "Electric Illumination at the Beginning of the Twentieth Century."

Through the abundant facilities afforded by the station, Dr. Bell will illustrate his remarks by frequent demonstrations.

Industrial Notes

THE WESTERN TELEPHONE CONSTRUCTION COMPANY, Chicago, Ill., announces that under its new management it has had for the past eight months done a most successful and ever-increasing business. Large orders have been filled and are continually coming in from cities all over the country, from Texas to Maine.

THE BRIDGEPORT BRASS COMPANY, 19 Murray street, N. Y., and Bridgeport, Ct., is mailing a neat, little, red-covered book, descriptive of its "Phono-Electric" wire. Dr. Leonard Paget's tables, made after severe tests of the wire, are contained in the book, which will be mailed upon application to the company's New York office.

MR. CHARLES A. OLSON, of the Crane Company, Chicago, Ill., formerly superintendent for the Westinghouse Company at St. Petersburg, Russia, was a recent visitor at the International Correspondence Schools, Scranton, Pa. Mr. Olson stated that a number of men in his employ in Russia were students of the schools. As instruction is carried on by mail, no difficulty is experienced in teaching students at a distance, and in fact the schools have students in over one hundred foreign countries.

CASE BROTHERS, Highland Park, Ct., manufacturers of insulating and fuller boards, and rope papers for electrical purposes, advise that they sell either direct to the consumer or through supply houses, and as they always carry a large stock on hand orders can be immediately filled. They number among their customers all the large electrical houses of the United States, and several in France and Belgium, one order having been recently received for 26 tons of one thickness alone of their product.

JOHN BURRY, 69 Broadway, Brooklyn, N. Y., has conducted an interesting series of experiments to ascertain the effect of alternating fields of magnetic force upon various inflammations and diseases primarily caused by the failure of the natural circulating and draining functions of the affected parts. Solenoids comprise the apparatus, and are actuated by a 60-cycle current. Mr. Burry claims that rheumatism has been eliminated by this method in 10 to 15 minutes. Writer's and telegrapher's cramp has also been successfully treated, and the inventor has maintained what is practically a free hospital for some time past to prove his theories, which he believes will prove, upon further development, to be a valuable acquisition to the science of electrotherapeutics.

E. B. LATHAM & COMPANY, 136 Liberty street, reports a satisfactory advance in the business of its export department, particularly in the line of house-wiring goods, bells, batteries, telephones, etc., for which substantial orders have recently been received. Orders from both South Africa and China, where the disturbed condition of the country seems to have stimulated the use of electrical material, were recently entered. From the East they have advices to the effect that Japanese competition is beginning to make itself sharply felt, and that while as yet most of the supplies made in Japan are cheap in quality and finish as well as price, in some lines they have secured a strong foothold and bid fair to rival this country in the struggle for their own and other Eastern markets.

THE AMERICAN ELECTRIC FUSE COMPANY, Chicago, announces that it has received the exclusive agency for the Sunbeam switchboard lamps. These are manufactured by the well-known Sunbeam Incandescent Lamp Company, and are of the highest grade of workmanship and finish. The company has also received a general agency for the sale of A. B. C., a battery compound designed to take the place of sal ammoniac, and which is guaranteed by them whenever sold. Free packages for trial are sent to any one requesting them. The American Electric Fuse Company also manufactures its old line of fuses, fuse blocks, lightning arresters, paper insulators, distributing boards, magnet wire, and telephone and telegraph wire connectors. It is the sales agent forthe McIntire specialties in the West.

L. B. ALLEN COMPANY, incorporated, Chicago, is in receipt of the following interesting letter from D. L. Fagnan, corresponding secretary for the National Association of Stationary Engineers, which speaks for itself.

CLEVELAND, OHIO, December 27, 1900.

L. B. Allen Company, Chicago, Ill.

Gentlemen—The "Allen Soldering Paste" is the best article of the kind I have ever used. My coolers are damp and wires corrode very badly. I had a No. 4 wire corrode nearly in two. I noticed it and scraped it clean and tried everything on it trying to solder same—I wished to solder another piece of copper wire over it, for it was in an inaccessible place—I then tried the "Allen Soldering Paste" and succeeded easily. I have changed some wiring since, and have done considerable soldering with the "Allen Paste," and pronounce it O. K.

Very truly yours,
(Signed) D. L. FAGNAN,
Engineer Swift & Company.

THE EUREKA ELECTRIC COMPANY, 157-167 South Canal street, Chicago, Ill., reports that its success and growth during the past year has been unusually rapid and satisfactory. Its new building at the address given above possesses facilities for manufacturing and for handling business which could not be attended to in the old quarters for lack of space. In the new building the basement is devoted to magnet making and the turning out of iron and steel work for power and electric light plants; the main floor to offices and general shipping and salesrooms; the second floor for stock, storage and raw materials; the third floor to telephone manufacturing; the fourth floor to manufacturing and assembling of switchboards; the fifth and sixth floors for machine rooms, plating, buffing, screw machines, lathes, etc., the entire floor space being over 50,000 square feet. The company also desires to state that its "Twentieth Century" catalogue, describing fully its lines of telephone apparatus, switchboards, protectors, and other items of interest, will be forwarded to anyone upon application.

THE VIADUCT MANUFACTURING COMPANY, of Baltimore, Md., and its predecessors, founded by Mr. Augustus G. Davis in 1871, started with two men who are still in the service, manufacturing telegraph instruments and district messenger boxes. In 1880 the present property at the Relay, Baltimore & Ohio Railroad, was purchased and occupied in making storage batteries, this company being the first to manufacture them in this country. In 1877, when the telephone was invented, Mr. Davis procured a license from the inventor to exploit the State of Maryland, and to manufacture telephones for the American Bell Telephone Company. Mr. Davis founded the American District Telegraph Company, of Baltimore and many other places; also the Gold & Stock Ticker System, of Baltimore, and later the Maryland Telephone Company; the Telephone Exchange Company, of Baltimore, which is now the Chesapeake & Potomac Telephone Company. Its factory at the Relay is one of the most extensive establishments in this country for manufacturing telephones, telegraph and district messenger appliances. It is operated by water-power and excellently located on the Baltimore & Ohio Railroad.

AMBITIOUS MEN, who desire to obtain better positions and higher wages, should investigate the free scholarship offer made in another column by the American School of Correspondence, Boston, Mass. Situated in a large city, which is a recognized educational and industrial centre, this well-known correspondence school has many natural advantages in teaching the theory of the trades and engineering professions. Without leaving home or losing time from work, the student pursues a thorough course of study under the direction of able instructors, who are always ready and willing to assist him. Instruction papers, prepared especially for teaching by mail, are furnished free. These papers, written in clear and concise language, as free as possible from technicalities, are claimed to be much superior to ordinary text-books on the subjects of which they treat. In addition, special information regarding any difficulties in their studies is furnished students without extra charge. It should be the ambition of every man to advance in his trade or profession. A mechanic with practical experience, supplemented by theoretical education, can command a better position than a man without such an education. The result of long experience in teaching by mail shows that no other method so fully meets the requirements of men who have but little time for study.

THE AMERICAN DISTRICT STEAM COMPANY, of Lockport, N. Y., which is the originator and patentee of the Holly system of underground steam distribution, has been in business for a number of years, and built over 200 steam plants in different cities of this country, reports that during the past year it has installed over twenty new plants, besides making additions to ones previously built. The majority of these steam plants have been built for the utilization of exhaust steam from electric and other power plants.

The subject of exhaust steam appeals especially to electric and power companies, who either regard their exhaust steam as a wasted by-product, or one from which they get small compensation by the use of condensers. It is a well-known fact that nearly ten times as many heat units in the form of steam must be generated as can be converted into mechanical energy through the medium of the steam engine. We find flowing from the exhaust pipe of the engine nearly 90 per cent of the steam after it has done its power work and which in addition to heating feed-water is available for heating buildings. The Holly system takes this valuable product and turns it to practical account. It is the impression of some that exhaust steam is saturated with moisture and that it does not contain an equal number of units of heat as compared with live steam. This is a fallacy. Steam at equal pressures has equal temperatures.

It is demonstrated from actual practice that the exhaust steam from each 100 horsepower of engines operated will heat from 1,000,000 to 1,300,000 cubic feet of space in average buildings in zero weather. Electric companies operating the Holly system of exhaust steam-heating report that their receipts from the sale of steam are enough to pay all their fuel expenses for the entire year of 12 months, and six per cent interest on their investment for steam mains.

During the past year the business of the company has increased to such a degree that it has found it necessary to enlarge its works to take care of the increasing number of orders. Among the cities in which steam plants were installed during the past two years are Erie, Wilkinsburg, Johnstown, Washington, York, Towanda, Pa.; Pawtucket, R. I.; Hornellsville, Newburg, N. Y.; Atlanta, Ga.; Seattle, Wash.; Youngstown, Ohio; Crookston, Minn.; Grand Forks, N. D.; Champaign, Danville, Ill.; Colorado Springs, Colo., and many others.

The company invites correspondence and to all queries regarding the Holly system careful replies will be made, printed matter supplied and full particulars given to anyone interested in the matter.